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ART. XL.—*On the Nature of the Induration in the St. Peters and Potsdam Sandstones, and in certain Archæan Quartzites, in Wisconsin;* by R. D. IRVING.

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IN his address before the Geological Society of London, delivered Feb. 20th, 1880, Sorby describes sands whose grains are bounded externally by crystalline faces, but have on the interior the ordinary rolled grains, the quartz with crystalline faces having been deposited as a coating on the irregular surfaces of the original grains. He also states that the deposited quartz is in "perfect optical and crystalline continuity" with the interior grains, each broken fragment having been changed to a "definite crystal." He shows, further, that such crystalline sands occur in the sandstones of various ages "from the Oölites down to the Old Red," and that they are commonly little coherent, but that in some specimens "a number of grains may often be seen cohering more strongly than the rest; and these show clearly that the cavities originally existing between the grains have been more or less completely filled with quartz. Moreover, on carefully examining the less coherent grains by surface-illumination, we can see, not only the planes and angles due to unimpeded crystallization, but also more or less deep impressions due to the interference of contiguous grains, thus proving conclusively that the deposition of crystalline quartz took place after the nuclei were deposited as a bed of normal

sand. The very imperfect consolidation sometimes met with is, perhaps, not so very surprising, when we reflect on the very small coherence of many large quartz crystals which are yet in close juxtaposition. However, it does seem probable that this crystallization of quartz sometimes contributes very materially to the cohesion of the grains in hard and compact quartzites. In such examples as the Gannister of the South Yorkshire coal-field we can see, in a thin section, that the grains fit alongside one another in a very striking manner, and it is only by extreme care that good proof can be obtained of the actual deposition of quartz between them. However, in the case of a highly consolidated sandstone from Trinidad, the proof of the deposition of quartz is as complete as possible; the outline of the original grains of sand is perfectly distinct, and the cavities between them are filled with clear quartz in crystalline continuity with the contiguous grains, so that the whole is a mass of interfering crystals, each having a sand-grain as a nucleus. The rock has thus been converted into a hard quartzite, almost like a true quartz rock, but differs from such quartz rocks as those of the Scotch Highlands in containing no mica crystallized *in situ*. All my specimens of these quartz rocks are really highly quartzose mica-schists; and, so far, I have failed in my endeavors to trace the connection between them and true sandstones, though possibly this could easily be done in some districts which I have not examined."

These very highly interesting and important observations of Sorby have received surprisingly little attention, and I had missed them altogether, so that it was not until after I had reached the conclusions and made most of the observations referred to in this paper, that I learned that he had preceded me by over two years in some of the most important points. I am able, however, to extend his conclusions in some important respects. What he regards as probable, viz: that the "cohesion of the grains in hard and compact quartzites" is due to this deposition of interstitial quartz, I find certainly true. But more than this, I find in certain Archæan quartzites, and presumably the same thing is true of many more, that the "metamorphism" has consisted entirely in this deposition of interstitial quartz. Still further, I find that these same quartzites grade directly into true mica-bearing quartz-schists, where the only change besides the formation of interstitial quartz has been the development of mica scales from intermingled kaolinic material in the original rock. I may, therefore, with propriety publish a brief account of my observations and conclusions.

In beginning recently a systematic microscopic study of the crystalline schists of the northwestern states, I selected the quartzites as likely to yield the most readily, to this sort of

investigation, evidence of the nature of the metamorphism involved in their formation. The frequent gradation of the most compact, non-granular, often vitreous quartzites into plainly arenaceous and even pebbly, water-deposited rocks, and the small number of minerals and consequent probable simplicity of any chemical reactions involved, encouraged me to hope that I might find some clue to the solution of the problem of their metamorphism. I had already been led by many considerations to suspect that the change which the original sandstones had undergone in becoming quartzites was rather in the nature of an interstitial deposition of quartz from impregnating siliceous waters, than of a re-crystallization, or molecular re-arrangement of the original quartz grains. Among the things that tended to confirm me in this suspicion was the fact that in the Potsdam sandstone of Central Wisconsin, which is for the most part a loose and even incoherent sandstone, made up of rolled quartz grains, I had in my work for the Wisconsin State Survey frequently observed portions which were more or less indurated, and plainly by quartz, there being no other indurated substance present. These indurated portions are sometimes irregular areas and again are confined to certain layers intercalated in the usual incoherent material. In general, the formation is more indurated in its lower portions. The amount of induration varies greatly, in some cases being a barely perceptible hardening, and again ranging through various degrees to an extreme in which the rock becomes a compact almost vitreous quartzite, the thin slabs ringing like steel when struck with a hammer. Now it is certain that in such an unaltered, nearly horizontal and wholly undisturbed formation as this sandstone is, these indurations can not be in the nature of the ordinary orthodox regional metamorphism through which the crystalline schists are generally believed to have passed. Moreover, I had often observed a peculiar hardening and vitrification of both this sandstone and that of the St. Peters, on exposed surfaces, which is plainly a result of weathering and therefore of a necessity wholly unlike such a thing as a general re-crystallization. This peculiar effect of weathering, which I have never until within a few weeks seen noticed in any publication,* presents itself generally in the shape of a thin shell, usually from a fraction of an inch to an inch in thickness, of lustrous, vitreous, watery-looking quartz. It is found also proceeding inwards from the sides of joint cracks; and where the

* In Geikie's Text Book of Geology, pp. 158, 333, the exposed blocks of Eocene sandstone which are known as "grey wethers" in Wiltshire, and which occur again in the region of the Ardennes in France, are spoken of as becoming, under meteoric influences, a kind of lustrous quartzite.

rock is much jointed and exposed, the induration has sometimes extended in for some distance.*

In preparing my first material for the study of the quartzites, I selected the Huronian quartzites of the Baraboo Ranges of Sauk Co., Wisconsin, and, for comparison, the various vitrified and indurated forms of the Potsdam and St. Peter's sandstones above alluded to. Beginning first with the Baraboo quartzites I noticed at once in many sections, as viewed in ordinary light, a distinct clastic structure, rounded grains of quartz, outlined often by a little film of iron oxide, making up most of the section, but with a clear quartz in the interstices. Often some of the quartz grains would seem ill-defined, and look as though they melted away into the interstitial quartz; an appearance which has been noted by other observers in sections of the quartz-rocks of various regions.† In polarized light, however, it was often observed that all appearance of a clastic nature would disappear, instead of being more prominently brought out, as in an ordinary sandstone. In place of the rounded grains seen in the ordinary light, would now be seen only a mass of interlocking quartz areas, presenting every appearance of having crystallized in their present positions. Close study showed that the larger part of the quartz, that appeared in the ordinary light to be interstitial, *polarized with the rounded grains*, i. e., the individual quartzes extended beyond the limits of the grains. If the apparently fragmental particles were truly so, this appearance could only be explained by a deposition of quartz in such a way as to have crystalline continuity with the original grains.

That the force of crystallization was able to finish a crystal, or to restore a broken crystal, after the lapse of many ages, was to me a new conception, and one which seemed to call for very rigid demonstration before acceptance. There was little difficulty in proving that the apparently fragmental quartzes

* As an instance of a completely vitrified layer in the Potsdam of Wisconsin, may be mentioned the fossiliferous rock of Silver Bluff in the Trempealeau Valley, Jackson Co. (Geology of Wisconsin, ii, p. 566); as instances of a less completely indurated rock, that of the quarry at Black River Falls depot, Jackson Co. (Geol. of Wis., ii, p. 566), that of the quarry near Grand Rapids, Wood Co. (Id., p. 564), that of the quarry near Stevens Point, Portage Co. (Id., p. 564), and that of the quarry at Packwaukee, Marquette Co. (Id., p. 579); and as instances of the quartzite-like weathering in the Potsdam, that of the Roche Écrit Bluff near Friendship, Adams Co. (Id., p. 573), and of Petenwell Peak on the Wisconsin River, Juneau Co. (Id., p. 572). St. Peters sandstone with a vitrified crust may be best seen on the bold cliff known as Gibraltar Bluff on the south side of the Wisconsin River in Columbia Co. (Id., p. 589), and in the isolated knob on top of the Arlington prairie, Columbia Co. (Id., p. 585). It should be said that at the time these places were described for the Geology of Wisconsin (1876), the writer had barely begun his acquaintance with microscopic lithology, whence it comes that these rocks have never been studied microscopically until now.

† A. Geikie, Text Book of Geology, p. 127.

were indisputably of that nature, while the proof that such a thing is possible as the deposition of quartz upon a quartz surface, in such a manner as to be crystallographically continuous with it, was also forthcoming. At this stage of the investigation I called to mind the description of rounded quartz grains enveloped in quartz crystals, given by the Rev. A. A. Young in this Journal for July, 1882. Mr. Young had long before sent me specimens of the sand showing this peculiarity, but the time had not served for their study. Mounting some of them now in balsam, a moment's study with the microscope sufficed to show—what Mr. Young had not spoken of in his paper referred to—that the enveloping water-clear quartz, furnished with crystal faces, was optically oriented with the enclosed rough-surfaced, rolled grains. In the loose New Lisbon sandstone, then, the new quartz found room to develop crystalline faces, because of the small supply of silica, while in the Baraboo quartzites the supply of siliceous material was so large as to cause universal interference and irregularly outlined areas, whence the non-clastic appearance in polarized light, and the occasional non-clastic appearance in the ordinary light when no iron oxide or rough surface was present to separate new and original quartz.

Proceeding now to an examination of the remainder of my material, I soon found, as I had by this time anticipated, that the induration was of the same nature throughout—in St. Peter's and Potsdam sandstones, as well as in the Archæan quartzites—and, indeed, that my sections showed a completely graded series from loose sandstone, in which the rolled grains were enveloped in crystals of deposited quartz, to the most compact and apparently non-granular quartzites, and even to highly schistose quartzites with a clayey admixture in which mica flakes had developed.

I may now describe briefly a series of specimens illustrating these different degrees of alteration, beginning with the least indurated.

The first specimen is of the Potsdam sandstone from the quarries at New Lisbon, Wis.—the same as described by Mr. A. A. Young in this Journal for July, 1881. It is a very fine-grained, pink- and white-mottled sandstone, from which the light is reflected in numerous sparkling points. The induration is distinct, but only slight, small fragments crumbling readily in the fingers. The crumbled sand, mounted in balsam, shows every grain edged with more or less of the deposited quartz, which is always optically continuous with the original grain. The line of junction between the new quartz and the old is always strongly marked, either by a contrast between

the cloudiness and worn surface of the original grain and the pellucidity of the deposited quartz, or by the presence upon the surface of the original grain of a coating of oxide of iron. Only the smallest of the grains seem to show perfect crystalline faces, the supply of new quartz having been so great as to produce some interference in most cases. This is indicated by the indentations observable in the crystalline outlines, as shown in figs. 1, 2 and 3, which represent grains of this sand as seen

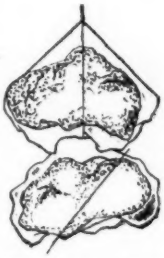
mounted in balsam. In this mounting the crystalline faces on the upper sides of the grains are not readily seen, but only the rough surfaces of the original grains, and the crystal outlines of the deposited quartz. The interference has, however, never extended very far, every grain showing some traces at least of the crystalline faces when viewed in a dry mounting. Evidently the small amount of induration in this sandstone is to be connected with this relatively slight amount of interference. As shown by Sorby,* the most perfect crystalline outlines are to be met with in quite unconsolidated sands, the quartz having then had full opportunity to develop perfect faces. In the figures drawn from the mountings of this sand, I have placed the three grains with their elasticity axes in a common direction.

The second specimen on the list is from the Potsdam sandstone of the quarry at the depot at Black River Falls, Wisconsin. It is a white, much coarser-grained, and perceptibly more indurated rock, than the last, but many crystalline facets of some size are perceptible. The cause of the greater induration becomes readily apparent when the balsam mounting of crumbled grains is examined. Every grain is coated with the deposited quartz, and usually has a broader border than seen in the grains of the New Lisbon rock. Only here and there are to be seen traces of distinct crystalline outlines, many grains showing no linear boundaries at all, while no single grain is without evidence of the interference of its deposited quartz with that of some contiguous grain. In fig. 4, two of the

* Op. cit., p. 37.

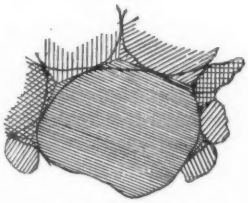
grains of this rock are shown in contact, the line drawn on each indicating the position of its elasticity axis. On the upper side of the upper one of the two grains the pyramidal outline is apparent, but below the deposited quartz of this grain interferes with that of the next one, upon which no linear outlines whatever are visible, the interference with the deposited quartz of contiguous grains having evidently been complete.

4.



The next specimen is one from an outlier of St. Peters sandstone, in the town of Arlington, Columbia Co., Wis. The larger part of the specimen shows a fine-grained, very loose, saccharoidal sandstone, in which there is almost no trace of induration, but in which numerous flashing points indicate the presence of crystal coatings to the grains. About one-fourth of an inch, however, on the weathered side of the specimen, presents the appearance of a completely vitreous quartzite. Seen under the microscope a thin section of this vitrified crust shows plainly the original rounded grains of the sandstone, but everywhere between them a deposited quartz which is divided off into areas coördinating optically with the original grains. The interference between the different areas of this deposited quartz has been nearly always too great to allow of the formation of crystalline outlines. Figs. 5 and 6 repre-

5.



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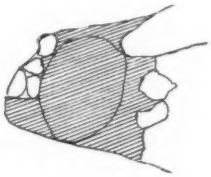
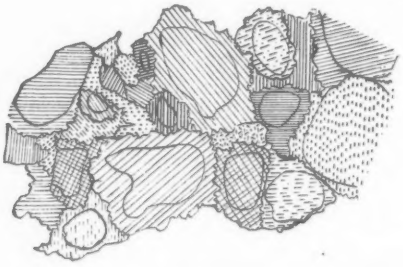


sent portions of the section of this crust. The smooth curved lines of the figures show the outlines of the original grains, while the shading indicates the way in which the original and deposited quartz polarize together.

The next specimen is one of St. Peter's sandstone from Gibraltar Bluff, a very bold and prominent point on the south side of the Wisconsin River in the town of West Point, Columbia Co., Wis. This rock is one which, if found among the crystalline schists, would undoubtedly be classed as a quartzite. It is a very much indurated, light-colored rock, in which a very fine arenaceous texture is perceptible only on the closest inspection. The thin section of this rock in polarized light shows

only interlocking grains of quartz. These interlocking grains are of two very different sizes, the larger ones predominating while the smaller here and there fill up spaces between the larger. Close study of this section in ordinary light brings out the fact that each of the larger ones of these areas, and here and there one of the smaller ones, is made up of a rounded, smoothly outlined worn grain, and a border of deposited quartz, the border and the worn grain within polarizing together. The outlines of the bordering quartz are exceedingly irregular, the different areas interlocking with one another more or less intricately. I have attempted to represent a portion of this section

7.



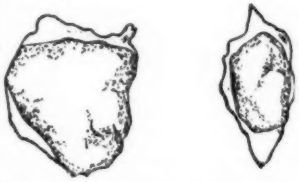
diagrammatically in fig. 7, the smoothly outlined areas of this figure representing as before the original worn grains and the different shading indicating the areas that are optically continuous. The lines marking the junction of the original grains with the deposited quartz are marked sometimes by a difference in the purity of the two quartzes, but more especially by the presence along the lines of flakes of ferrite and of numerous cavities, the ferrite flakes evidently representing a ferruginous coating on the surfaces of the original grains, while the cavities are plainly produced by the great irregularity of the surfaces upon which the new quartz was deposited. Some of the smaller areas of interstitial quartz above alluded to may have been wholly produced by deposition, the infiltrated quartz in this case not coördinating itself with original grains. It would evidently be difficult, however, to prove this to be the case, since the outlines of the original grains are now perceptible only when they were well coated with iron oxide or were rough enough to produce cavities in the deposited material.

The next specimen is from the Archæan quartzite of Devil's Lake, Wis. As I have indicated elsewhere* the larger portion of the quartzite of this region is without arenaceous appearance, being usually of a non-granular, flakey texture, and of a color

* Geology of Wisconsin, vol. ii, p. 505.

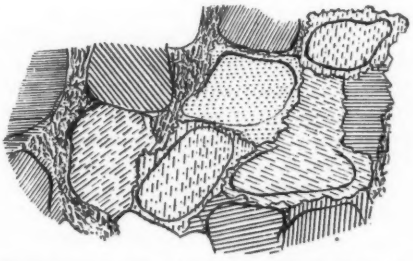
from nearly white, through gray, pink and purple to purplish-red, and even brick-red. Now and then a tendency to an arenaceous texture is observable, and occasionally small areas are little more than moderately indurated sandstone. It is from one of these least indurated portions that the present specimen is taken. The rock is only a little more indurated than that above described as from the Potsdam of Black River Falls. The sand broken from this specimen and mounted in balsam is seen to be precisely like that of the Black River Falls rock, except that the interference has been too great to allow the formation of any crystalline outlines in the deposited quartz. The rock is, however, much further from a true quartzite than either of those above described from the St. Peter's sandstone. Figures 8 and 9 represent grains broken from this rock.

8. 9.



The sandstone thus described grades immediately into a more indurated rock. A specimen taken a few inches rom it shows a rock much like that of the St. Peter's at Gibraltar Bluff, both as to texture and amount of induration; and this resemblance is borne out by the appearance of the thin section, which shows—as does also that of the Gibraltar rock—rounded grains surrounded by closely interlocking areas of deposited quartz coördinated optically with the original grains. The only distinction of importance between this rock and that of Gibraltar Bluff is the presence in it, here and there, of an interstitial kaolinic material, made up of minute brilliantly polarizing flakes of kaolinite. Figure 10 is drawn from the thin section

10.



of this rock, the smooth curving lines as before, indicating the outlines of original grains, and the zigzag lines, the intersections of different areas of deposited quartz; while the shadings indicate the manner in which the new quartz polarizes with the old.

Within a few inches from the point at which the specimen

last described was taken, the rock has become hard, vitreous, purple quartzite, without trace of arenaceous appearance; in other words the ordinary quartzite of the region. The thin section of this rock, in polarized light, shows no trace whatever of a fragmental origin, the grains being completely interlocked, but in ordinary light, here and there, may be distinctly seen the rounded outlines of an original grain, polarizing with the deposited quartz surrounding it. As in the Gibraltar rock, so also in this section, there is much of a fine interlocking interstitial quartz which may have been in part or wholly deposited.

A step beyond the last specimen described is shown by another from a point farther east, on the same quartzite range in the town of Caledonia, Columbia Co., Wis. Microscopically this specimen shows numerous large quartz fragments embedded in a finer non-granular matrix, which is distinctly schistose, being apparently a clayey quartzite. At first sight the thin section of this rock seems to show no trace of fragmental origin, being made up of relatively large quartz particles embedded in a matrix composed of finer angular quartz particles and much of a kaolinic material. The quartz grains show throughout a tendency to have their longer axes in a common direction. Occasionally in the finer matrix are developed small but distinct muscovite scales. Close study of the section brings out here and there the same feature as heretofore noted, namely, the presence in the interlocking angular quartzes of cores composed of rounded grains. The section of this rock is indistinguishable from a number that I have examined of the argillaceous quartzites of the Lake Superior Huronian.

It thus appears that the alteration which has produced from sandstone certain Archæan quartzites and quartz-schists is of the same nature as the induration which affects—quite independently of any igneous action—irregular areas in wholly undisturbed and elsewhere wholly unaltered sandstones, and even as the surface induration produced in some sandstones by mere weathering. All of these changes are due to the deposition of interstitial quartz in such a manner as to be crystallographically continuous with the original clastic particles.

The origin of the saturating quartz is a point of great interest. In the case of the indurated crust it seems evident that the deposited silica has accumulated at the surface by evaporation and capillary action on a relatively minute quantity of a siliceous solution permeating the rock. The only probable origin for the silica in this solution seems to be in the action of the atmospheric waters upon occasional feldspar particles in the sandstone. A similar origin may be assigned for the silica of

most of the indurated rock of the St. Peter's and Potsdam sandstones; but in some cases there are indications that the induration has followed lines of faulting, where the silica may be extraneous.* In the case of the Archæan quartzites of the Baraboo region an extraneous source is suggested by the frequent occurrence in these quartzites of strings and veins of white quartz, often supplied with cavities lined with quartz crystals.

University of Wisconsin, Madison, Wisconsin, February, 1883.

ART. XLI.—*On the existence of a deposit in Northeastern Montana and Northwestern Dakota that is possibly equivalent with the Green River Group;* by CHARLES A. WHITE.

[Published in advance by permission of the Director of the U. S. Geological Survey.]

THE great fresh-water Eocene series of strata known as the Green River Group occupies, as is well known, a very large region in Southwestern Wyoming and the adjacent parts of Utah and Colorado; but in the absence of positive evidence it may well be doubted whether the strata of that group ever extended much if any to the northward of the 43d parallel of latitude. Last summer while studying the Laramie Group, in the region of the Lower Yellowstone River, I found a small deposit lying nearly upon the 47th parallel of latitude which, in consequence of its stratigraphical relations, its lithological character, and the fact that it contains small Teliost fishes, is strongly suggestive of identity with the Green River Group. The deposit is only a few acres in extent, and lies upon the top of an elevation known as Sentinel Butte, two or three miles east of the boundary line between Dakota and Montana, three or four miles south of the Northern Pacific Railway, and about fifty miles east of the point where that railway reaches the Yellowstone Valley.

The whole region between the Yellowstone and Missouri Rivers, north of the parallel of 46°, as well as much of the Upper Missouri River country adjacent to this region, is occupied by the Laramie Group, which at few and distant intervals in the valleys of those rivers is seen to rest conformably upon the Fox Hills Cretaceous group.

The strata in this whole region are approximately level except in a few localities where limited flexures occur. The geology of the region is therefore exceedingly simple. The Lara-

* See T. C. Chamberlin's description of the formation at Ironton, Wis., Geol. of Wis., vol. iv.

mie Group I estimate at about 500 feet maximum thickness in that region, but it has everywhere suffered such extensive erosion that I am not satisfied that I have seen its uppermost layers at any point except at Sentinel Butte, and one other similar butte forty-five miles to the northwestward of it.

Sentinel Butte lies between the Little Missouri, a tributary of the Great Missouri River on the east, and Beaver Creek, a tributary of the former, on the west. Along the divide between these two small streams there are numerous buttes composed of the material which has escaped the great and general denudation that the region has suffered, and which constitute the principal features of the landscape. The strata of which these buttes are composed are approximately horizontal, and the fact is apparent at a glance that the intervening lower lands have been made such by erosion. While the surface of this region is more completely grass-covered than that of the region directly southward on the Great Plains, the exposure of the strata which underlie the surface here is general, and their order of superposition is easily traced.

The Laramie Group within the region in question is made up of variously colored sandy shales and Bad-land sandstones, with numerous beds of lignite and carbonaceous material. In many places the beds of lignite have been burned out, giving a conspicuous brick-red color to the strata thus affected. From its junction with the Fox Hills Group in the Yellowstone Valley, the strata of the Laramie Group were traced out into the country upon either side, and up into the higher lands, including the buttes before mentioned; of which Sentinel may be taken as an example.

This butte rises about three hundred feet above the general level of the land around it, and the characteristic strata of the Laramie Group, including its lignite, are readily traced to within one hundred feet of the flat, nearly level top. Resting conformably upon these Laramie strata we find about sixty feet in thickness of coarse sandstone strata, the lower half being more thinly and evenly stratified than the upper. This sandstone presents a precipitous front at almost all sides of the irregularly shaped butte, to which it gives the appearance of a massive cap in the distance.

Resting directly and conformably upon this sandstone is a mass of light gray fissile calcareous shales which, to one familiar with the aspect of the typical shales of the Green River Group, at once suggests their identity. These shales are plainly a remnant that has escaped erosion, and were found to occupy an area at the top of the butte estimated at forty acres, and their maximum thickness at forty feet. The presence of the coarse sandstone was detected at the top of a few others of the higher

buttes in this region, but the fissile shales were found only on Sentinel Butte. It is probable, however, that they will be found at the top of other buttes in that region.

Searching these shales I found the two species of fishes which are described in following paragraphs by Professor Cope, but no other traces of fossils of any kind were discovered in them. It will be seen from Professor Cope's remarks that these fishes are not closely related to any hitherto described, and they are therefore not of service in directly identifying the strata from which they come with the Green River Group or with any other. They are, however, of such a character that they may have lived in such lacustrine waters as the Green River Group was deposited in.

In the absence of paleontological evidence we must rely upon the stratigraphical relations of this deposit in considering its claim to be regarded as a part of the Green River Group. I am by no means confident that this small deposit is a part of that group, and once continuous with the same to the southwestward; or that it is in any sense equivalent with the same; but the following facts are worth considering in that connection.

(1.) This small fish-bearing deposit follows in regular order, and rests conformably upon certain sandstone strata, which in turn rest conformably upon typical Laramie strata. The Green River Group at its typical localities in like manner rests conformably upon the Wahsatch Group which in turn rests (in many places at least) conformably upon the Laramie Group.

(2.) The lithological characteristics of this fish-bearing deposit are surprisingly like the fish-bearing layers of the Green River Group.

(3.) Although the fishes of this deposit are not identical with any known forms in the Green River Group, their characteristics are such that no reason is apparent why they may not have lived at the same time and in similar, if not the same, waters as those that have been discovered in that group.

(4.) Their nearest affinities are with fishes that have been found in the Green River Group, and none like them have ever been found in the Laramie Group.

It may be objected that in the Green River region the great Wahsatch Group exists between the Green River and Laramie Groups; and that it has not been shown to be present in connection with the small fish-bearing deposit in question. In reply it may be remarked that although so thin, the coarse sandstones between this small fish-bearing deposit and the Laramie strata on Sentinel Butte may be reasonably supposed to represent both the Lower Green River Group of Powell and the Wahsatch Group of Hayden. Indeed it seems plausible that

whether the typical strata of either the Green River or Wahsatch Groups were ever continuous with these northern strata or not, we have in that upper one hundred feet of Sentinel Butte the chronological representatives of the Upper and Lower Green River and the Wahsatch Groups combined. Whatever the facts of the equivalency of the strata here discussed may be, I have no doubt that the small fish-bearing deposit in question was laid down in waters that immediately succeeded the close of the Laramie Group, and that it is not properly a part of the same although it rests with apparent conformity upon it.

The following is Professor Cope's description of the fishes referred to in the foregoing remarks:

On a new extinct genus and species of Percidæ from Dakota Territory; by E. D. COPE.

The specimens of fishes submitted to me by Professor C. A. White represent four individuals and two species. These belong apparently to the Centrarchine division of the Percidæ, and although the future discovery of the structure of the ventral fins may invalidate this conclusion I do not anticipate such a result. I am also unable to determine whether there are teeth on the vomer or not. As regards generic affinity the species do not enter any of the genera now known from American or European Tertiary formations, as will be seen from the characteristics about to be given. They differ from those of the recent genera of Centrarchinæ, in the entire, circular outline of the operculum; and from some of them in the anal fin with five spinous rays originating posterior to the line of the anterior border of the spinous dorsal fin. This new genus I name *Plioplarchus*, and give the following diagnosis. Family characters, etc.: Mouth bounded above by premaxillary bone only. Branchiostegal rays seven, possibly eight. Ventral fin commencing below the base of the pectoral. Scales ctenoid.

Generic characters: Teeth few, simple and conic. No indication of large pharyngeal bones. Preoperculum entire posteriorly and at the angle; inferior edge unknown. Operculum rounded, entire. One dorsal fin. Anal fin commencing below the middle of the spinous dorsal; with five or more spinous radii. Caudal fin openly emarginate. Lateral line continuous, uninterrupted.

The species may be described as follows:—

Plioplarchus Whitei Cope.

General form elongate oval, the dorsal and ventral outlines of the body about equally convex. The length of the head enters that of the head and body to the extremity of the caudal

vertebræ, three times; and the depth of the body at the ventral fins enters the same two and two-thirds times. The muzzle is short and obtuse, and the mouth opens obliquely upward. The orbit is very large, and enters the length of the head to the border of the operculum three times, and is one-third of itself longer than the muzzle.

The radial formula is: D. IX−12; C+17+; A.V−14; V.?; P. 13. All the soft rays are fissured distally. The dorsal spines increase in length to the last one, as do also the anals. The pectoral rays reach to below the sixth dorsal spine, and beyond the extremity of the ventral fin, which does not quite reach the anal. The soft rays of the anal extend to a point below the extremity of the vertebral column, forming a well-developed fin. The extremity of the soft dorsal is lost. The external rays of the caudal fin are a little longer than the median. The spine of the ventral fin is not strong. The caudal peduncle is moderately narrow. The vertebral column is convex upward anteriorly: no., caudal XVI; abdominal XII to the edge of the operculum. A caudal vertebra preserved in place has two lateral fossæ separated by a horizontal keel. The abdominal cavity extends posterior to the anterior spinous rays of the anal fin, so that the anterior interhæmals are directed upward and backward. The ribs are long. There are four interneural bones anterior to the dorsal fin. The postcoracoid is elongate.

There are seven or eight longitudinal rows of scales visible above the vertebral column, and sixteen below it; the size diminishing rapidly downward. All the bones of the head excepting the muzzle and jaws are covered with scales. There are six rows on the cheek below the eye. The scales of the body have the basal radial grooves and ridges few and coarse. The external surface is finely but strongly rugose with tubercles or grains, with a trace of fine concentric lines across the superior and inferior edges. Marginal denticles small. The interior faces of the scales which cover part of the fossil display numerous very close and fine concentric lines, with a small triangular rough area extending from the edge toward the center.

Measurements:

Total length, with caudal fin	.116[m]
Depth at front of dorsal fin	·033
Length of caudal fin to base of vertebra	·0247
Length of caudal vertebra	·0365
Length of base of dorsal fin	·0325
Length of base of soft dorsal	·015
Length of seventh dorsal spine	·017
Length of third dorsal ray	·020

Length of fifth anal spine	·0165
Length of fourth anal ray	·022
Length of base of anal fin	·0245
Length of pectoral fin	·020
Length of ventral fin	·017
Depth of caudal peduncle	·012
Depth of head at orbit, posteriorly	·026

The typical specimen of this fish is in excellent preservation. The species is dedicated to Dr. C. A. White, the distinguished geologist and paleontologist.

Plioplarchus sexspinosus Cope.

This species is represented by two specimens, both of which lack the head and body anterior to the dorsal fin. One of the specimens is accompanied by its reverse. The differences between this species and *P. Whitei* are to be seen in the radial formula. This shows more numerous spinous, and less numerous cartilaginous, rays. The formula is: D X—13; C+17+; A. VI—9. The last anal radii are somewhat injured, and these may have been more than nine, but no trace of others exist and it is clear that they were less numerous than in *P. Whitei*. There are about eighteen series of scales below the vertebral column at the front of the dorsal fin. Their external surfaces are not so rough as in *P. Whitei*, as the granules are confined to the center of the scale, and in the concentric lines are much more obvious, and form a wider border. Ctenoid denticles distinct. Caudal fin openly emarginate.

Measurements:

Depth at anterior edge of anal fin	·0206[m]
Length from do. to the end of the caudal vertebræ	·0305
Length of caudal fin to vertebral centra	·020
Length of base of dorsal fin	·0282
Length of base of soft dorsal	·015
Length of base of anal	·017
Length of base of spinous anal	·008
Length of ninth dorsal spine	·013
Length of fifth anal spine	·015
Depth of caudal peduncle, about	·011

Remarks:—

Among the known extinct types of fishes it is *Mioplosus* Cope that approaches nearest this one. The former is characteristic of the Green River beds of the Lower Eocene. The genus *Plioplarchus* does not enable me to identify the horizon from which it is derived with any of our known formations. It only permits the general statement that its age may be Tertiary or Upper Cretaceous.

ART. XLII.—*On the Peculiar Concretions occurring in Meteoric Irons;* by J. LAWRENCE SMITH, Louisville, Ky.

FOR some time after meteorites, either stony or iron, became special objects of interest, little attention, comparatively, was given to their chemical and mineralogical constitution, and it is not much over forty years that good and reliable information on these points has been furnished. Much of the work that has been done deserves to be repeated by our improved methods as regards both their mineralogy and chemical constitution. This study is necessary in order to guide us in the future to some correct view of their lithological position in the universe.

My object at the present time is to refer to one point, in connection with the structure of the irons, that has occupied more or less critical study on my part since 1851, the results having been published from time to time without my attempting to generalize them. Reference is here made to the concretions in the interior of meteoric irons, the larger and more important ones being of a nodular character, or more or less globular.

In some of these irons no visible concretions have been developed by the sections of them that have been thus far made. Notably among this class is the Dickson County iron, that was seen to fall in 1835. Whether this would hold good, if many more sections of it were made, we cannot tell. I have not seen them in any sections of the Braunau iron, which was also seen to fall, but my observations on this last iron have been limited. There are other meteorites of which the time of fall is not known that can be placed in the same category. But the presence of concretions is the general rule.

What are these concretions? Those which first attracted attention, on account of their size and constancy, were composed essentially of sulphur and iron, so well and widely known in the Seelasgen iron, sections of which were early and largely distributed among mineral cabinets.

The second kind of concretion noted is of a brighter yellow color than the last, with which it was long confounded, until Partsch pointed out that it consisted essentially of phosphorus and iron; it is seen in a very marked manner in the Lockport, Toluca, Tazewell and many other irons.

A third concretion, of a dull black color, frequently more or less mixed with the sulphuret, was found to be a form of graphite, as in the Sevier and Toluca irons.

A fourth concretion, found by me in two different irons, was in small parcels and consisted of protochloride of iron.

A fifth concretion I discovered in 1876 in the Cohahuila masses, called the Butcher meteorites. It is second to none in interest, having marked mineralogical and chemical characteristics to be referred to under its proper head, it being a sulphuret of chromium and iron.

A sixth concretion is one I have but recently discovered. I have as yet found but one specimen, but that of some size and well marked. The specimen is in a polished slab of about twelve inches square, which is now in the hands of Professors DesCloizeaux and Daubrée for inspection, and for the present in the cabinet of the Garden of Plants. It is chromite. The list of concretionary minerals does not terminate here, for there are others of obscure character in the interior of some of those already mentioned, which will be referred to as we make a short statement respecting their manner of occurrence and composition.

Sulphuret of Iron (Troilite, FeS).—The nodules of this mineral are larger than those of any of the others yet found in the interior of meteoric iron, some of them weighing from 100 to 200 grams. As in the Toluca and Augusta County irons, they are most commonly globular, and they are often very numerous in the iron. It is not my object to enter into any detailed mineralogical description of them, for they are well known by their dark bronze color, which color in troilite of the pure type extends unaltered to the very boundary of the enclosing iron. They are either granular in structure, or more solid with a marked cleavage in one direction; the latter kind I have found to be the purest form. It is readily acted on by dilute chlorhydric acid, especially when slightly warmed, and is completely dissolved, thus distinguishing it in a marked manner from some of the other concretions to be referred to. It was for some time considered identical with the magnetic sulphuret of iron (pyrrhotite); but my labors in 1853* proved it to be a protosulphuret of iron (FeS); and further examinations with the purest specimens have confirmed the first results. Rammelsberg and others have, by independent analyses, sustained this determination. Troilite is hence a meteoric mineral having no terrestrial representative.

The iron immediately enclosing these nodules, and within a milligram or two of them, gives but a trace of sulphur on analysis. The finest type of pure troilite I found is in the Sevier County iron, although this iron contains nodules of it largely mixed with other minerals.

Schreibersite (Phosphuret of iron and nickel (Ni_2Fe_4P).—We do not have to go far in the examination of troilite nodules before finding some of them coated or penetrated by a bright

* This Journal, vol. xix.

yellow mineral, quite like some sulphurets of iron but unlike troilite. It is also found in fissures and small irregular cavities, but I have not yet seen it in independent globular concretions. While all forms of schreibersite are interesting, what most attracts the attention of the geologist and mineralogist is its association with troilite, as in the irons of Lockport, Toluca, Tazewell County, Pittsburg, etc. The nodules of troilite in these irons are completely coated with it, the line of demarcation being well-defined. In a section of the Lockport iron that is in my cabinet several nodules of troilite 2^{cm} in diameter have the coating from 1 to 2^{mm} in thickness. On bringing a magnet near to the smaller fragments it is attracted almost as readily as iron, while troilite is barely affected by the magnet. Sulphur is not found in this mineral, although so closely adherent to a sulphuret; and the inclosed troilite contains only a trace of phosphorus although there are 14 per cent in the schreibersite. Its composition and formula as made out by me in 1853* is: Phosphorus 15·47, iron 55·36, nickel 29·17, corresponding to Ni_4Fe_4P. My examinations of other specimens obtained from other meteorites, some in very minute crystals, have proved all to have the same composition. This fact is mentioned because some have supposed that there is another similar phosphuret differing in composition from the above. As yet I have no chemical evidence of this.

The insolubility of schreibersite in chlorhydric acid facilitates the obtaining of it in a pure state, as by this means the last traces of adhering troilite are detached. By means of this reaction, aided by its magnetic property, I have obtained all the pure schreibersite needed for investigation. There has not yet been found any terrestrial mineral like schreibersite.

Graphite.—The next concretion that is most conspicuous in certain meteoric irons, although it cannot be called common, is of the character of graphite. That it is a true graphite is placed beyond all doubt, first by the experiments of M. Berthelot,† who formed graphitic oxide with the material obtained from the Cranberry iron, and by my own experiments made upon graphite from the same iron, and also from other irons, as the Sevier County and the Toluca.

The largest nodule of graphite that has been seen in any meteorite is the one described first by Troost, afterward by myself, which came from the Sevier County iron, and weighed originally 92 grams;‡ a section taken from it in the direction of the longest diameter is now in the cabinet at the Garden of Plants. Most frequently the graphite present is largely mixed

* This Journal, vol. xix, p. 151.

† Annales de Chem. et de Phys., iv–xix, 392, 1870, and xxx, 419, 1873.

‡ Researches in solid carbon compounds in meteorites. This Journal, May and June, 1876. Ann. de Chem. et de Phys., 1876.

with troilite. It is never crystalline in structure like that in the interior of cast iron; it is quite like the graphite of Cumberland, England. On treatment by ether or petroleum spirits, a minute quantity of a crystalline substance is dissolved, that will be referred to later on as mixed with sulphur.

Daubréelite.—This is one of the most interesting concretionary products in meteoric iron. I discovered it in 1875, in the Butcher meteorites; and since then I have found it in other meteorites, but so finely divided and mixed through troilite nodules that it would have escaped notice altogether had it not been for its very marked and prominent mode of occurrence in the above mentioned meteorites.

Being easily separated from the iron, I was enabled to study its properties thoroughly, and thereby furnish a process by which it could be detected in other meteorites when completely obscured from the eye.

This mineral occurs in the Butcher meteorites in the manner already fully described.* It is commonly associated with troilite; but the lines of demarcation are so distinct that particles of the pure mineral are mechanically detached without difficulty. Its composition is now well known to be $FeS+CrS_2$, being analogous to terrestrial chromite, with the oxygen of the latter replaced by sulphur. There is no terrestrial mineral of the same composition.† Full details of its mineral characteristics, chemical composition, etc., are found in a previous publication.

Chromite.—The most recently discovered concretion is that described by me as found in a section of the Butcher meteoric iron. This unique specimen consists of an entire nodule, 12×17^{mm}, of nearly pure chromite; and being an oxygen-bearing mineral, it is of special interest in this connection. It is contained in a section of the iron about twelve inches square, which is at present in the Mineralogical Museum of the Garden of Plants at Paris.‡ In mass it is perfectly black; in small fragments under the microscope it is translucent and of a dark ruby color. This translucence of chromite was first noticed a few years ago by an assistant of M. Fouqué of the College of France.

Lawrencite.—This mineral, so-called by M. Daubrée, I first found in the Tazewell meteoric iron as described by me in 1853,§ and still later in the Rockingham iron. It is a solid green protochloride of iron with probably nickel. The quantity obtained was small and could not be analyzed.

* Comptes Rendus de l'Acad. des Sciences, 1876.

† This Journal, vol. xvi, Oct., 1878, will be found a full and complete account, analyses, etc.

‡ Comptes Rendus de l'Acad. des Sciences, 1881.

§ This Journal, vol. xix, p. 151, 1853.

Aragonite.—I first discovered carbonate of lime in small quantity concreted on the Newton County meteorite,* a stony meteorite. It was in the form of calcite. In 1876 I found considerable of a crust of aragonite on two specimens of the Butcher meteoric iron from Mexico.† But in neither of these instances do I consider the carbonate of lime as belonging to original meteorites, the incrustations having taken place after their fall. But all the other concretions referred to came originally with the meteorites.

Each of the concretions enumerated, in all six excluding the last, is almost as characteristic of meteoric iron as the nickeliferous alloy of the metal. It is true that we find graphite segregated in artificial iron from the blast furnace, but in this iron it is always in crystalline flakes, which I have not found in meteoric iron.

The above facts do not exhaust the interesting facts connected with these concretionary minerals of meteoric iron—for some of them, if not the majority, are somewhat complex in their character, being mixtures of the various substances found in two or more of the purer nodules; and besides there are other compounds not visible to the naked eye and only reached by chemical means. I will describe some of them that are complex and give the method of separating the different compounds.

Before, however, passing to this part of the subject I will say a word about *Celestialite*, for, while it does not occur in a concreted form in any part of meteoric iron, it is found associated with the graphite, and also in the troilite containing graphite. A full description of it has already been given.‡ M. Berthelot has supposed that the ether used in the experiments had something to do with its formation, but I have since repeated all my former experiments with petroleum ether in his presence with similar results.

There is also an undefined *Cobalt mineral* occurring in the troilite of some of the veins, which will be referred to beyond.

Compound nodules.—The difficulty of obtaining a sufficient quantity of these concretions from many irons, has circumscribed my research to those coming from three irons: 1st, the Toluca iron, which furnished material in sufficient quantity only for a partial examination; 2d, the Cranbourne; and 3d, the Sevier County—the latter two furnished the principal materials for my research.

I will simply detail my process with the results from the

* This Journal, vol. xliii.

† This Journal, vol. xii, 1876.

‡ This Journal, May and June, 1876.

treatment of a nodule of eight grams of a compound troilite nodule from the Cranbourne iron, for this is most accessible to any one desiring to repeat the experiments. This nodule was very finely powdered and treated with petroleum-ether (boiling under 72° C.) for about one hour, filtered and washed with the same petroleum, and the entire amount of liquid evaporated slowly to dryness. This gave me a few minute crystals of *celestialite* mixed with sulphur. But as this substance is so enveloped in the mineral matter, it is only in a subsequent part of the process that the greater part of the celestialite is obtained.

After the treatment by petroleum, the dried powder is treated by dilute chlorhydric acid (1 acid to 1 water) and warmed over a water bath for an hour or two, and after all action has ceased more acid is added (1 acid to 1 water) for about half an hour; this will dissolve entirely all the troilite with the evolution of SH_2, leaving a black residue. The solution of troilite is filtered and the residue washed. The troilite solution was analyzed and found to contain a very minute quantity of nickel, 0·40 per cent, and the merest trace of cobalt; sometimes more of the cobalt will be found than nickel, but this arises from another mineral in the compound nodule that has been partially attacked. The residue was then treated with petroleum-ether in the manner already stated, and the filtered solution on slow evaporation in a small beaker gave beautiful long needle-shaped crystals that weighed ·045 grams—a mixture of sulphur with a sulphur-carbon compound. The residue from the last irons was treated twice over a water bath with strong chlorhydric acid, and the soluble portion filtered off and concentrated gave a greenish-blue solution which heated with nitric acid did not acquire a red color and on analysis was found to contain cobalt-oxide with a little nickel, ·028; iron oxide, ·105; chrome oxide, ·008. The little chrome coming from the amorphous daubréelite to be alluded to a little further on. The residue from the last was dried on a water bath and spread out carefully and a magnet applied to it, when a large portion of it was attracted, amounting to ·603 grams, composed of microscopic square prismatic crystals which doubtless were what G. Rose called Rhabdite,* but which is schreibersite for I have obtained it from other meteoric irons by treating them with chlorhydric acid, and then verifying the composition of the crystals by analysis.

The part which was not magnetic was then treated with nitric acid, evaporated to dryness, and treated again with a little nitric acid and water and filtered; an intensely green solu-

* Rose found it in square prismatic crystals in the Braunau iron, but he could not determine either its composition or precise crystalline form.

tion is obtained, composed of Cr ·010, Co ·015, Fe_2O_3 ·028; in fact it is daubréelite with cobalt and oxide of iron coming from an unknown cobalt compound that had made itself very manifest in a previous part of the examination.

The residue, which has been now reduced to a few milligrams, is found to be graphite with a few minute particles of a siliceous mineral. The only novel feature of importance in the results above stated is the appearance of considerable amounts of cobalt in certain parts of the process. It is evident that this is not a part of the composition of the troilite, for chlorhydric acid removes this latter mineral and but a trace of cobalt is found in the solution; it is only after further and prolonged treatment with concentrated chlorhydric acid that the cobalt appears abundantly in solution with comparatively little iron; and it even requires a further treatment with nitric acid before it is all dissolved; then it is mixed with the daubréelite. My conclusion is that it comes from a mineral in the compound nodule first operated with, in which cobalt is a prominent constituent; but whether it is a sulphuret or phosphuret I have no means of ascertaining, but in order to note its prominent position I have thought proper to state this fact. In the analyses of troilite nodules, I have several times noticed that when they are completely dissolved, while but a trace of nickel is found, a notable quantity of cobalt manifests its presence.

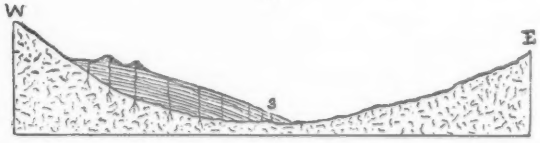
These are the prominent points that I wish to call attention to at this time as regards these concretions. The question naturally arises, do they in any way serve to indicate the manner in which the original masses were formed. While it is impossible from what we yet know to clear up this question, I am more and more confirmed in the belief that the iron was at one time in a plastic state from the effect of heat. Some may think otherwise from the fact that petroleum-ether dissolves sulphur and sulphur carbon compounds from the concretions in the iron. But the fact is that my observations and experiments on cast iron show that this objection has no weight. As by a proper treatment I dissolve crystals from most cast iron by the agency of ether or petroleum-ether—a note of which fact I have already publicly announced—my experiments on this point are both clear and convincing although I have not yet completed them. So far as they have gone they were shown experimentally to M. Berthelot and others, and if my health permits I shall complete them before many months.

ART. XLIII.—*On Mineral Vein formation now in progress at Steamboat Springs compared with the same at Sulphur Bank;* by JOSEPH LECONTE.

I RECENTLY visited Steamboat Springs for the purpose of comparing the phenomena there exhibited with those previously observed at Sulphur Bank and described in this Journal of July last. These springs have already been described by Phillips and Laur.* I shall, therefore, give only such brief description as is necessary to make my comparison intelligible.

The springs are in Washoe Co., Nevada, about fifteen miles south of Reno and immediately on the railroad to Carson and Virginia City. The place is, therefore, easily accessible, and, being a health-resort, there are good accommodations for visitors. The springs issue in a narrow N. and S. valley with volcanic ridges on each side, the vents being mainly on the slope of the western ridge. On nearing the place by cars, the attention of the traveler is strongly attracted by the clouds of condensed steam issuing from many vents over a bare rocky space about the hotel and extending northward a half mile or more. On closer examination the vents are seen to be separate, but occurring in linear series, showing that they are connected by continuous fissures. These fissures may be traced from vent to vent often as a vein, filled by a deposit of silica from the hot alkaline waters. The separate vents, especially at the south end of the fumarole area, are each on the top of a gently sloping mound (some of which are 15 to 20 feet high) formed by deposit from the water. The mounds, however, run together at their bases and form a continuous crust of silica. Toward the northern part of the area the crust is still more evenly continuous. It forms here, in fact, a continuous rounded shell-like deposit, firm, hard, and ringing under the

1.

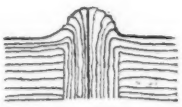


heel, about 2 to 3 hundred yards wide, at least a half mile long and 15 to 20 feet in thickness. This clean, hard, shell-like crust lies against the slope of the western hill and reaches to near the bottom of the valley. (Fig. 1.)

* Laur, Annales des Mines, for 1863, p. 423. Phillips, Phil. Mag., 1871, vol. xlii, p. 401.

We have said that about the hotel the vents are mostly separate but arranged on lines which were evidently fissures. These fissures are some of them open, some partly filled but water still issuing from a narrow crevice in the middle, some wholly filled with deposit. The deposited silica occurs in almost every conceivable form—most commonly as tufaceous sinter in thin horizontal layers, sometimes with beautiful agate-like structure, sometimes milky chalcedonic, and sometimes saccharoid quartz. Everywhere the horizontal-banded structure is conspicuous and in some cases the filling of fissures by successive deposits has given rise to a vertical banded structure like that found in veins. Fig. 2 is an ideal section of such a vein of the natural size. This structure, however, was by no means so conspicuous as I had been led to expect from the descriptions of previous observers. The deposits in many places are stained and clouded with metals, especially iron oxide and cinnabar. Wherever the issuance of the hot water is still going on slowly the silica is found in a gelatinous condition. Other observers have found in small quantities many other metallic sulphides, and even free gold is said to have been found in these sulphides. Here then undoubtedly mineral veins are now forming under our eyes, but their metallic contents are in very small proportion.

2.



In the more northern portion of the fumarole area, as already stated, the crust is more continuous and extensive and probably thicker. This part was therefore probably at one time the principal seat of fumarolic action, but the active vents are now very few. This whole area is intersected by a system of open parallel fissures of great size and differing somewhat from those already mentioned. They are seven or eight in number, and the five largest are at least half a mile long, a foot wide, about twenty-five feet apart and apparently 20 to 30 feet deep. They are tortuous with rough ragged edges and evidently reach to the bottom of the crust. Water does not now issue from them but can be seen and heard seven or eight feet below, in violent agitation from the escape of steam and carbonic acid (fig. 1). There is no evidence that it ever issued from them; for their sides and edges are sharply jagged like a fracture unmodified by subsequent deposit. The water in them seems to issue lower down to the east and north, where are found active vents and even feeble geyser eruptions which are said to have been more violent at one time than now.

It will be seen then that there are indeed here fissures filled and now filling with quartz veinstone of ribboned structure and containing metallic sulphides, yet these are not fissures and

veins in the country rock, but only in the *crust deposit*. The country rock is completely buried under this crust probably 20 to 30 feet deep, and therefore completely concealed from view. The hot alkaline waters loaded with silica seem to have deposited so abundantly that they cover and choke up their own vents, while other vents are constantly formed by the expansive force of steam fissuring the crust previously formed. The great fissures described above were probably formed in this way, and perhaps opened by a slight bodily sliding of the crust toward the bottom of the valley. The analogy of the filled fissures to veins is not so complete as I had expected, or as it is at Sulphur Bank. If we could get beneath the crust and find fissures in the country rock filled by deposit, then indeed the analogy would be complete. This is exactly what we actually find at Sulphur Bank. In the immediate fumarole area, the country rock is concealed, but wherever not covered by deposit its character is evident. On the hill slope and in the valley to the very margin of the deposit it is everywhere a quartz-trachyte or rhyolite. Along the crest of the western ridge, however, there is an outburst of black, very basic rock, probably basalt. This ridge is probably a basaltic dyke breaking through a rhyolitic country rock. It is not improbable that the fumaroles are the feeble remnants of a volcanic activity inaugurated by the basaltic outburst.

Cinnabar mines in the vicinity.—About a mile to the westward of the springs, cinnabar mines have been opened and reduction works established. A considerable amount of cinnabar has been taken out, but the work is now abandoned. Here the surface appearances are entirely different from those at Steamboat Springs, and more like those at Sulphur Bank. There is no crust deposit, but on the contrary the whole hillside rock is decomposed by acid vapors into a white chalky earth like that at Sulphur Bank, except that in this case the rock being rhyolite, the chalky earth is full of disseminated grains of free quartz. Tunnels have been driven into the hillside at various levels and the ore extracted from the decomposed earthy matter, but the sound rock has not been reached. In this loose earth are found in considerable quantities both cinnabar and sulphur—the former in streaks as if deposited in water-ways, the latter more irregularly and widely distributed as if formed by oxidation of sulphuretted hydrogen gas. In some places sulphates of iron and alumina are very abundant, even more so than at Sulphur Bank. There can be no doubt, therefore, that here there came up, and probably are still coming up, hot waters containing alkaline carbonates and alkaline sulphides, carrying in solution and depositing sulphides of mercury and iron by cooling, and by oxidation depositing also sul-

phur and forming sulphuric acid. In a word the phenomena are here very similar to those at Sulphur Bank, except that here the up-coming solfataric waters are less abundant and perhaps less rich in metallic sulphides. This, however, can only be determined with a certainty by deep explorations.

Comparison of Steamboat Springs with Sulphur Bank.—A comparison of the phenomena at these two places is interesting. The surface phenomena, it is seen, are very different; in fact in complete contrast. At Steamboat Springs the whole country rock is covered 20 to 30 feet deep and completely concealed by a hard crust of deposited silica; at Sulphur Bank, on the contrary, there is no crust but only a soft chalky residue from the acid decomposition of surface rock—a residual silica from which the bases have been all extracted. The reason of the difference is obvious. At Steamboat Springs the hot waters contain mainly alkaline carbonates carrying silica in solution, while at Sulphur Bank they contain also largely alkaline sulphides and carry metallic sulphides in solution. A crust cannot form at Sulphur Bank because the silica is not brought to the surface, the up-coming alkaline waters carrying silica being neutralized before reaching the surface by the down-going acid waters. The chalky residues of acid decomposition of the surface rocks, so conspicuous at Sulphur Bank, do not occur at Steamboat Springs, because the alkaline sulphides are in too small proportion to produce any conspicuous effects by oxidation; whatever of rock decomposition occurs there, must be alkaline, not acid—by removal of silica, not of bases. Such alkaline decomposition doubtless does occur beneath the crust at Steamboat as it does at Sulphur Bank below atmospheric influences. Again, since alkaline sulphides are the solvents of metallic sulphides, at Steamboat Springs the deposits are almost pure silica—only stained here and there with metallic oxides and sulphides; while at Sulphur Bank the metallic sulphides, especially mercuric sulphide, are in large quantity. At the abandoned cinnabar mines near Steamboat Springs, alkaline sulphides, carrying metallic sulphides, again occur, but here again also, these are associated with the surface phenomena characteristic of solfataric waters.

At the California Geysers—so-called—we find also solfataric action with its invariable accompaniment of acid decomposition of the surface rocks with earthy residue, but the freight of valuable metallic sulphides seems to be less abundant there, probably only because not met with in the course of the up-coming waters. Iron sulphide, however, is abundantly deposited. In *true* geysers like those of Yellowstone Park and Iceland, the super-heated waters contain usually only alkaline carbonates, and therefore carry in solution and deposit only silica.

Thus then, we have a connected series of deposits from super-heated waters, their characters depending upon the composition of these waters: 1. In true geysers the waters being pure alkaline carbonates deposit only silica. 2. At Steamboat Springs there are some alkaline sulphides, and, therefore, some metallic sulphides, but not enough to prevent a crust of deposited silica. 3. At the California Geysers—so-called—solfataric action is conspicuous and therefore no crust is formed, but only earthy residue of acid decomposition of surface rocks. Here we have also metallic sulphides deposited, but these are of little value. 4. At the cinnabar mines, near Steamboat Springs, we have solfataric waters depositing cinnabar and other metallic sulphides in considerable quantity, but whether in profitable quantity cannot be known certainly unless deeper explorations be undertaken. 5. Finally, at Sulphur Bank, the deposit of metallic sulphides is abundant and the formation of metalliferous veins is illustrated in the most perfect manner on account of the deep explorations undertaken at this place.

In connection with the idea so common, that the metals are derived immediately from igneous rocks, it may be well to draw attention to the fact, that igneous rocks are by far most abundant and igneous action most conspicuous at Yellowstone Geysers and at Steamboat Springs, where there are little or no metals; while at Sulphur Bank the country rocks beneath a depth of 20 to 30 feet are stratified sandstones and shales of Cretaceous age, the igneous rocks being very superficial and evidently contributing nothing to the metalliferous deposits. It would seem that igneous *action* supplies a necessary *condition* (heat) for the formation, rather than that igneous *rocks* supply the *materials* of metalliferous veins.

ART. XLIV.—*Observations of the Transit of Venus, Dec. 6th, 1882, at the Vanderbilt University Observatory, Nashville, Tenn.;* by OLIN H. LANDRETH, Professor of Engineering, Vanderbilt University.

BY the courtesy of Dr. L. C. Garland, Chancellor and Professor of Astronomy of this institution, in granting me the use of the University Observatory during the Transit of Venus of Dec. 6th, 1882, I am enabled to make the following report of the observations and results obtained in connection therewith. All times here expressed are in terms of Washington mean time, and are dependent on the value of the longitude herein given.

Observations of external and internal ingress were wholly

prevented by clouds which continued to obscure the sun almost without interruption until $6^d\ 1^h\ 12^m$, after which the sky remained clear during the day.

Instrumental Constants and Circumstances.

Adopted latitude of equatorial dome $= +36°\ 8'\ 58''{\cdot}25$.
Adopted longitude of equatorial dome $= +0^h\ 39^m\ 0{\cdot}68^s$ from Washington.

Aperture of equatorial	= 5·95 inches.
Focal length of equatorial	= 97·00 inches.
Magnifying power used	= 210 diameters.
Value of one revolution filar micrometer screw I	= 21″·1803.
Value of one revolution filar micrometer screw II	= 21″·1297.
Diameter of cross-wires in filar micrometer	= less than 0″·34 (15 measurements).
Aperture of transit circle used for time determination	= 3·92 inches.
Focal length of transit circle used for time determination	= 54·00 inches.

The adopted latitude and longitude depend on the position of the astronomical station of the U. S. Coast and Geodetic Survey, located on the grounds of the Tennessee State Capitol in Nashville, which station was connected with the Vanderbilt Observatory by a traverse survey executed by my engineering students, with an engineer's transit and a suspended fine steel wire corrected for deflection, temperature and inclination. The adopted value of the astronomical position of the coast survey station as furnished me by the office is:

Latitude $= +36°\ 10'\ 1''{\cdot}37$.
Longitude $= +0^h\ 38^m\ 55{\cdot}897^s$ **from Washington.**

The adopted clock correction—the probable error of which is $\pm{\cdot}066^s$—is the result of twenty star transits extending from Dec. $5{\cdot}3^d$ to Dec. $6{\cdot}5^d$, including four circumpolar pairs for azimuth, three reversals for collimation and seven level readings, all systematically distributed, and reduced by least squares involving unknown quantities for azimuth, collimation, clock rate and correction to the assumed clock error.

The value of one revolution of the micrometer screw was determined by eighty-one transits of equatorial stars covering a range of temperature of 20° C., without revealing any temperature effect. The quantity ″·34 stated in connection with the diameter of cross-wires in the filar micrometer is one-half the "double distance" between the two positions of symmetrical tangency of one wire with the other, as determined by the narrowest possible line of light visible between the two wires.

Final Results.

Times of Contacts.

Internal egress	"suspected,"	(*a*)	Dec. $6^d\ 2^h\ 40^m\ 10{\cdot}3^s$	Washington	mean time.
" "	"certainly past,"	(*b*)	" $6^d\ 2^h\ 40^m\ 28{\cdot}0^s$	"	"
External egress	"suspected,"	(*c*)	" $6^d\ 3^h\ 1^m\ 9{\cdot}3^s$	"	"
" "	"certainly past,"	(*d*)	" $6^d\ 3^h\ 1^m\ 23{\cdot}8^s$	"	"

Filar Micrometer Measures of Planet's Diameter.

Polar diameter = 62″·941 (4 observations), mean at $2^h\ 25^m\ 6^s$.
Equatorial diameter = 63″·247 (4 observations), mean at $2^h\ 34^m\ 35^s$.

Remarks on the Observations.—Concerning the phenomena seen at the two recorded instants (*a*) and (*b*) my note-book says: "The two recorded times at third contact are those at which the narrow band of light between the sun's limb and planet became so narrow and faint as to cause 'suspicion' and 'certainty' of its being only the light around the planet. At 10^s or 11^s after 'suspected,' (*a*), I glanced to see if tangency had yet occurred and found it, as near as I could judge, perfect, and again saw it certainly past just before 'certainly past,' (*b*), which was recorded when the narrow band of light had *certainly* quieted down into a *Venus halo*." This closed band of light continued visible for about 20^s after (*b*), and remained as an arc of 45° from sun's limb on north side of planet until $2^h\ 48^m$. At fourth contact the recorded times (*c*) and (*d*) are those at which the obliteration of the notch on the sun's limb was "suspected" and "certainly past." The obliteration was accompanied by a rather more than usual disturbance at this point of the limb of the sun. Through the kindness of Capt. G. W. Stockell, Chief of the Fire Department of Nashville, time signals were struck on the fire-alarm bells of the city at $8^h\ 00^m\ 1^s$ A. M. and at $2^h\ 00^m\ 00^s$ P. M. Vanderbilt mean time. Time was taken and recorded for me during the observations by J. T. McGill, Ph.D., Fellow and Assistant in Chemistry. I am also indebted to Assistant Engineer W. B. Boggs, U. S. N., Instructor in Engineering, for assuming charge of the distribution of time signals, as well as to C. L. Thornburg, B.E., Fellow and Assistant in Mathematics, for efficient and extended assistance in the determination of time and instrumental constants. In order to give Mr. E. E. Barnard the advantages of the observatory time-determination and geographical position, he was invited to observe the Transit from the observatory grounds. This he did, having his time-sounder in electric circuit with the observatory sidereal clock. His results are given in his letter appended. I am gratified to be able to state that Mr. Barnard has since been appointed to a fellowship in astronomy in this institution.

March 30, 1883.

Transit of Venus, Dec. 5th and 6th, 1882; as observed by Mr. E. E. Barnard.

Latitude +36° 8′ 57″·88. Longitude $39^m\ 0{\cdot}781^s$ west from Washington.

The following are Observed Times of Phenomena described, Washington mean time.

II.	III.	*a.*	*b.*	IV.
$21^h\ 16^m\ 32^s$	$2^h\ 40^m\ 50^s$	$2^h\ 41^m\ 40^s$	$2^h\ 46^m\ 29^s$	$3^h\ 1^m\ 15{\cdot}78^s$

Point of observation, about 200 feet west of Vanderbilt Observatory telescope. Five-inch Byrne refractor mounted as a simple equatorial, with tangent screw motion in R. A. Magnifying power for contacts 173, used with wedge-shaped sun prism. Time obtained from the observatory by means of a telegraphic *sounder* beside the observer, and in circuit with the observatory Dent sidereal clock. Several minutes before and after calculated contacts, the minutes and intervening ten seconds were called from the observatory.

First contact lost in dense clouds.

Second contact uncertain, the sun being glimpsed for a moment; Venus seen, I am confident, at or very close upon contact; this time is noted as II. Clouds until afternoon. When a view was permitted, careful observations were made; no light spots seen. An optical phenomenon was constantly present, a large brown spot two-thirds the diameter of Venus covering the middle of the planet; viewed obliquely it was thrown slightly to one side staining the sun a bright yellow; the planet otherwise was of a violet color; brown spot only seen with high powers. Several times a faint ring of light was noticed around Venus, only certainly seen when thin clouds cut down the bright background.

Third contact, definition very poor from heated air, and too much reliance should not be placed on this observation; black drop formed before the limbs were quite in contact; the time, III, was when the limbs were tangent, as estimated through the black drop, and probably a little late. A small arc of light was visible round Venus at the point of contact, which at time marked *a* was protruding sensibly outside the sun. This outlining of the planet's protruding limb remained visible for several minutes, the arc increasing as the planet emerged; presently about two-thirds of the arc to the northwest entirely disappeared, leaving a delicate horn of light projecting from the sun's limb around the southern part of Venus; this remained quite conspicuous until the time marked *b*, when it disappeared completely, though closely looked for; no similar object was visible at the other side of the planet.

At fourth contact, definition was much improved. The last glimpse of the planet against the outline of the sun was that marked IV; a few seconds later Venus was certainly gone. I think this observation can be relied on as being very close.

Full aperture was used at second contact without any sun-shade. The other observations were with aperture reduced to $4\frac{1}{2}$ inches.

ART. XLV.—*On the Fauna found at Lime Creek, Iowa, and its relation to other Geological Faunas;* by S. CALVIN, State University of Iowa.

A PAPER by Professor H. S. Williams, in this Journal for February, 1883, "On a remarkable Fauna at the base of the Chemung Group in New York," appears to me to record more than one remarkable discovery. The finding of fossil species at High Point, New York, identical with species that have heretofore been known only from the Rockford Shales, along Lime Creek above Rockford, Iowa, is a most interesting fact and well deserves immediate record. In discussing the significance of his discovery, however, the author of the above-mentioned paper, misled no doubt by information from untrustworthy sources, has fallen into a few errors that, in the interest of clearness in geological matters, should be set right.

For the better understanding of the questions involved let me give a catalogue of the Lime Creek fauna as far as the species have been described. Some of the species enumerated below have not been catalogued from this locality by previous writers, but my own collections, made personally, embrace all the species of this list, except *Leiorhynchus iris* which is included on the authority of Mr. R. P. Whitfield.

Stromatopora incrustans H. & W.
Stromatopora expansa H. & W.
Stromatopora solidula H. & W.
Caunopora planulata H. & W.
Fistulipora occidens H. & W.
Alveolites Rockfordensis H. & W.
Aulopora Iowensis H. & W.
Aulopora saxivadum H. & W.
Zaphrentis solida H. & W.
Campophyllum nanum H. & W.
Chonophyllum ellipticum H. & W.
Cystiphyllum mundulum H. & W.
Pachyphyllum solitarium H. & W.
Pachyphyllum Woodmani White.
Acervularia inequalis H. & W.
Smithia Johanni H. & W.
Smithia multiradiata H. & W.
Stomatopora alternata H. & W.
Crania famelica H. & W.
Strophodonta arcuata Hall.
Strophodonta canace H. & W.
Strophodonta variabilis Calvin.

Strophodonta exilis Calvin.*
Strophonella reversa Hall.
Strophonella hybrida H. & W.
Streptorhynchus Chemungensis Con.
Orthis impressa Hall.
Productella dissimilis Hall.
Productella truncata Hall.
Spirifera Whitneyi Hall.
Spirifera Hungerfordi Hall.
Spirifera orestes H. & W.
Spirifera cyrtinæformis H. & W.
Spirifera fimbriata Con.
Spirifera Macbridei, n. s.†
Cyrtina Hamiltonensis, var. *recta* H.
Atrypa reticularis Lin.
Atrypa hystrix Hall.
Rhynchonella contracta, var. *saxatilis* H.
Leiorhynchus iris Hall.
Leiorhynchus (undescribed species).
Gypidula occidentalis Hall.
Terebratula navicella Hall.
Cryptonella Calvini H. & W.
Paracyclas Sabini White.
Naticopsis gigantea H. & W.
Undetermined *Orthocerata.*
Plates of Placoderm fishes allied to *Dinichthys.*

That the High Point fauna, as given by Professor Williams, bears a close resemblance to the Lime Creek fauna, will be admitted by all competent judges; but that a fauna in which Atrypas and Strophodontas predominate among the brachiopods, and which includes Alveolites, Acervularia, Smithia,

* This species was described by me in the Bulletin of the United States Geological Survey of the Territories, vol. iv, No. 3, as *Strophodonta quadrata.* This name, however, was preoccupied by Professor Swallow (Proceedings St. Louis Academy of Science, 1860), and I, therefore, propose to substitute the above name in place of that originally applied.

† This fine species of Spirifera is not very rare in the Rockford Shales. It differs from all described forms in many important particulars. The shell is of medium size, more or less pyramidal or cyrtina-form; hinge line equal to greatest width of shell but with the cardino-lateral angles scarcely produced. Ventral valve sub-pyramidal, hinge area very wide and slightly concave, the plane of the area forming an acute angle with a plane passing between the valves. Mesial sinus broad, shallow, with a low, rounded ridge down the middle. Dorsal valve slightly convex, mesial fold well defined regularly rounded, protruding in front in the middle line owing to the ridge in mesial sinus of opposite valve. From twelve to fourteen low, rounded plications on each side of the mesial fold and sinus, which are large near the middle of the shell, and decrease toward the lateral margins. Entire surface very finely granulose; the granules in some places, particularly on the mesial fold and sinus, being arranged in very close-set, radiating lines. Imbricating lamellæ and lines of growth are crowded concentrically on the anterior half of each valve. Length, 23^{mm}, width 36^{mm}. Height of hinge area, 16^{mm}. Width of foramen at base, 10^{mm}. This species is named in honor of Professor T. H. McBride of the State University of Iowa.

Chonophyllum and Cystiphyllum among its corals, is "*strikingly Carboniferous in aspect*" (this Journal for February, p. 98) is an opinion that will not be shared by many paleontologists. Even the little Productus, *Productella dissimilis* Hall, that Professor Williams regards as so "*decidedly Carboniferous in aspect*" (10th line, 1st par.) is a true Devonian type; and there is not another species in the whole list that even remotely suggests any Carboniferous affinities.

Spirifera fimbriata, as far as I know, occurs in eastern strata belonging to the Upper Helderberg and Hamilton; not in the Chemung. Now the specimens found at Lime Creek agree in size with the Upper Helderberg rather than with the Hamilton forms, a fact that, so far as it has any significance, points toward the lower Devonian rather than in the opposite direction.

Several years ago I found a few cystideans in Devonian strata near Iowa City, one of which has been described by Dr. C. A. White as *Strobilocystites Calvini*. Previous to this discovery it had been very generally supposed that the cystideans became extinct in the Upper Silurian; certainly they did not persist very far into the Devonian. Nevertheless, last year, at another locality near Iowa City, I found the Lime Creek species, *Productella dissimilis* and *Spirifera Whitneyi*, in a thin bed of shale *associated with plates of cystideans*. The significance of this fact does not need to be stated.

Then again, in 1876 and 1877, a number of Lime Creek species, including *Productella dissimilis*, were found associated with a peculiar fauna in some black shales below the limestones at Independence, Iowa. This fact was noted by me in a paper published in the Bulletin of United States Geological Survey, vol. iv, No. 3, in 1878. The Independence limestones have been referred by all geologists who have studied them, to the Hamilton, though Dr. Barris refers beds containing a similar fauna at Davenport, Iowa, to the Upper Helderberg. *Acervularia profunda*, *A. Davidsoni*, *Phillipsastrea gigas* and some other species that occur in the Independence limestones, are found in strata that have been referred to the horizon of the Upper Helderberg in Canada and Ohio. For a shell with a "decidedly Carboniferous aspect," *Productella dissimilis* has the somewhat questionable habit of always keeping company in Iowa with Lower Devonian types.

In a note in this Journal for April, p. 311, Professor Williams withdraws the statement near the top of page 99, that Professor Worthen had referred the Lime Creek beds to the Kinderhook; but the statement farther on, on the same page that "the Lime Creek fauna is certainly more closely related to the fauna of the Kinderhook group of Missouri, Indiana and Illinois than

to any other fauna of the West," should not be accounted for on the theory of misleading publications in respect to western geology. In fact, not a single species of the Lime Creek fauna has yet been recognized in all the Kinderhook of Missouri, Indiana and Illinois. Not only are all the known species different in the two formations, but very few even of the Lime Creek *genera* are represented in the Kinderhook. Of the Atrypas and Strophodontas that constitute so conspicuous a feature of collections from Lime Creek, the Kinderhook has not so much as a single representative. It would be a more hopeful undertaking to attempt to prove a close relationship between the fauna of Lime Creek and the fauna of the Niagara than to prove such relationship between the Lime Creek and Kinderhook faunas. At least one species is common to the first two, the *Atrypa reticularis*, and the genera are strikingly similar as shown in the following table:

Niagara.	Lime Creek.	Kinderhook.
Stromatopora,	Stromatopora,	
Alveolites,	Alveolites,	
Cystiphyllum,	Cystiphyllum,	
Strombodes,	Smithia,*	
Strophodonta,	Strophodonta,	
Strophonella,	Strophonella,	
Streptorhynchus,	Streptorhynchus,	Streptorhynchus,
Orthis,	Orthis,	Orthis,
	Productella,	Productus,
Spirifera,	Spirifera,	Spirifera,
Atrypa,	Atrypa,	
Pentamerus,	Gypidula,	
Rynchonella.	Rhynchonella,	Rhynchonella.

Some genera omitted from the Lime Creek list are not represented in either of the other two groups. A glance at the table will show on which side the relation is most marked, and yet I think few geologists would claim that any very close relationship exists between the Lime Creek and Niagara faunas.

The fish faunas of the Lime Creek and Kinderhook beds do not help matters very much. In the first we have fragments of plates of Devonian Placoderms; in the second we have beds crowded full of the teeth of *Cladodus* and other Carboniferous Hybodonts.

The last sentence of Professor Williams's brief note in the April number of this Journal might have been omitted. "The exact relation of the Lime Creek beds *to other deposits of the west*" is not in question so far as I know; but the particular New York horizon with which, not only these beds, but all our Devonian strata are to be correlated, is questioned by some and hence "not satisfactorily determined." The discovery at

* The two species of Lime Creek fossils referred to *Smithia* are certainly not generically distinct from *Strombodes*. (See remarks of Rominger on this point, Geol. of Mich., vol. iii.)

High Point, N. Y., would seem to indicate that the Lime Creek beds are equivalent to the lower part of the New York Chemung; yet it must be conceded that the mingling of Upper and Lower Devonian features in the Lime Creek fauna, and in all the Devonian fauna of Iowa as well, leaves the question of exact equivalency still doubtful.

Speaking for the Kinderhook beds of Iowa and Illinois,* it may be positively asserted that Devonian types are wholly absent from the included fauna; while the Hybodont fishes, the Crinoids, the representatives of the *Productidæ*, and other groups of fossils, all assume Carboniferous features which ally the Kinderhook with the Burlington and other undoubted Subcarboniferous strata.

ART. XLVI.—*Observations upon Stratified Drift in Delaware;* by F. D. CHESTER.

IF a line should be drawn from the city of Wilmington to the village of Newark until it touched the Maryland boundary line, it would follow approximately the southern limit of the Archæan rocks of the State. These gneissic and schistose strata strike in the common northeast and southwest direction and dip at high angles to the southeast. Resting upon the southern flanks of the latter rocks, occur unconformable Cretaceous strata, whose subdivisions and positions exactly correspond to those of the New Jersey series. The dip of these latter Cretaceous clays, sand and marls is so small that the surface of the country is extremely level. The Archæan region, on the contrary, is one mass of hills, separated not by wide but by extremely narrow valleys, and generally by mere hollows, depressions or ravines.

Examinations throughout this hilly country point distinctly to the fact that these elevations and depressions have been carved out by the forces of erosion—these forces being ordinary aerial disintegration of the gneissic and schistose rocks, and erosion along drainage lines.

That mere hollows entirely surrounded by hills could have been dug out only by aerial disintegration is certain. These enclosed hollows serve to separate the majority of all the elevations of this Archæan region. Often hollows connect hollows by short passages, the hills sloping in all cases gradually. Often, again, hill-slope will meet hill-slope, while the ravine separating winds along for distances varying from a few hundred feet to several miles. Still oftener it is seen that hill

* Some authors still regard the Goniatite beds of Rockford, Indiana, as possibly Devonian.

slopes are scarred by broad shallow gouges. To describe all the details of form in this irregular but picturesque region would be impossible, but what has already been said suffices to present the main forms of relief. That many of these forms must be attributed to direct aerial disintegration of the rock, now going on with such rapidity in this region, is quite certain.

The main reason for this may be attributed to the varying power of durability which these rocks are known to possess. Some of them, those containing an excess of black mica, resist to some extent the forces of disintegration, while those mainly composed of feldspar easily decay. We know further, as practically observed in this region, that this rock disintegration is carried on more through the presence of moisture and soakage waters than through direct atmospheric contact, hence no doubt the collection of waters in hollows and along certain lines has been a great factor in the work.

But that this erosion was not entirely aerial in character is evident. The creeks of the region wind for miles through valleys, no doubt largely due to their own waters; for the flat lands of the valleys, wherever observed, are underlaid by stratified sands and rock fragments, all of gneissic origin. Into the valleys open narrow ravines, usually the course of some brook, and underlaid by the highly stratified gneissic sand and fragments. These ravines wind in and out for miles, and were no doubt once the channels of larger streams. Into these latter ravines still other ravines are often found to enter. The last system of valleys and ravines we must regard as the work of running water, but even in this case aerial disintegration must have acted also; for the sides of these valleys and ravines are the steeply sloping hills, the soil of which has resulted from the decay of the underlying rocks.

Thus the two main forces of erosion throughout this Archæan country have been aerial decay and erosion. Wherever the former force has acted, the soils are disintegrated rock in place, *and such is characteristic almost entirely of this region*, while, wherever the latter force has acted, the flat lands of the valley and ravine are made of stratified materials.

If now we extend our examinations of the surface geology south of the Archæan hills, to the drift deposits which overlie the Cretaceous clays, we find a different order of things. Instead of the common gneiss-made soil in place, we find no connection between surface deposits, and the underlying formation. Examinations of the soils from various localities determine clearly their gneissic origin. Quartz grains, finely rounded, hornblende particles, rounded but with less smooth surfaces, particles of white mica and rarely grains of magnetite. The

clay present was the element giving variety of color to the soils and was found coating and cementing the particles.

To sum up the results of numerous observations upon the surface deposits we have the following general section:

Surface soil	6″—18″
Yellow clay	6′ —14′
Red sand and water-worn pebbles, highly stratified	4′ —12′

The yellowish clay shows clearly its gneissic origin. This bed when seen wet in the digging of wells has the appearance of being highly plastic, but when dried this coherence is lost and the material is found to be made up of very fine particles of gneissic origin. The red sand was entirely free from clay and was merely the coarser materials of gneissic origin, constituting water worn quartzose pebbles, fragments of gneiss and mica schist, coarse particles of mica and coarse quartzose sand colored red by the oxide of iron resulting from the decomposition of hornblende.

That this latter bed of red sand does not form a part of the Cretaceous clays is proven by the fact that it is also found to overlie the upturned edges of the Archæan strata along their southern margin, just at the foot of the hills. Further the complete absence of the red sand in the region of the marl beds would indicate its gradual thinning out before that point is reached, while the overlying clays continue on to the south and directly cover the true geological formations. This latter surface deposit extends to the lower limit of New Castle County, beyond which point examinations have not been carried. Besides the thick layer of argillaceous soil extending from the Archæan hills to the lower limit of our explorations, there are often seen, in the southern portion of the county, local patches of white and yellow quartzose sand, which show no apparent stratification, and were probably of dune origin.

Still further we have to note certain peculiarities of the surface geology of Delaware. The Cretaceous plain, just south of the gneissic hills, is characterized by swells and undulations of the land, which gives the country in places a gently rolling character. These swellings are found to be made up of the stratified yellowish loam, mixed with rounded quartzose pebbles. It often happens that this stratification of the soil was no way appparent, but whenever the materials became coarse, such stratification was distinctly seen.

The exact position of these forms in the classification of drift phenomena is uncertain, unless they be termed, after Hitchcock, *Terrace-moraines*. Their origin is still more uncertain, and the only probable explanation is some checking of the motion of the waters at certain points, whereby a greater amount of material was deposited in particular localities.

There are two facts which seem to point to the depth of the waters in which the stratified drift of northern Delaware was deposited. The first of these is the presence of stratified sands upon the top of Polly Drummond's hill, 250 feet above the Cretaceous plain. This elevation is well known as the highest point in the State, and therefore the highest point at which such deposits could have been made. The materials were well-washed reddish and yellowish quartzose sand, unassociated with pebbles, and the section seen showed the most eminent stratification running in a horizontal direction. The second fact is the occurrence of two hills of unstratified glacial detritus and bowlders three miles to the south, called respectively Iron and Chestnut Hills (see this Journal, Jan., 1883). These hills are no doubt piles of débris dropped from one or more ice-floats moving upon the surface of waters which covered the region. The highest of these elevations is 227 feet above the level of the Cretaceous plain upon which the hills rest.

Upon the very top of the highest elevation, the whole surface is strewn with enormous bowlders of dolerite, a few of which measure twenty-five feet in circumference. It is quite evident that so large bowlders could have been transported only by floating ice-rafts, while their present position upon the very summit of one of the hills was probably due to the fact that the ice-floats must have been carried upon the surface of water which was higher in level than the tops of the hills. But perhaps the most conclusive proof of all, in this latter connection, regarding the depth of the waters, is the slightly modifying action which in places this unstratified drift has undergone, for upon the very top in an excellent cutting, I saw in places a perfect arrangement of the materials, showing the slight modifying action of the water over the top of the hill.

The height of the Cretaceous plain at Newark, the level from which my elevations were measured, is 80 feet above mean tide; if then we should add to this 250 feet, the height of Polly Drummond's Hill, we shall have 330 feet as the least rise of the sea above its present level; which we must remember means nothing more than an equivalent depression of the land during the Champlain period. Such a depression of the land would have covered the entire peninsula with one sea or estuary connecting the Delaware with the Chesapeake. The waves of this estuary beating against the upturned gneissic and schistose rocks of the north would spread out upon its bottom the sands and gravels which overlie the clays. The cold currents from the north fed by the melting glacier would produce conditions unfavorable to marine life, and hence the absence of shells in this red sand. The total thinning out southward of the latter deposit is entirely characteristic of all sea-border

formations, and hence we are safe in attributing to it this origin. At this time the Archæan depressions had not yet been carved out, but merely a universal sea spread over the whole peninsula depositing the sands of Polly Drummond's Hill, while upon the surface of the waters, ice-rafts floated southward dropping the materials of Iron and Chestnut Hills, and scattering the bowlders found in various parts of New Castle County.

When at the close of the Champlain period, the land began to rise toward its present level a deep estuary was changed into a shallow one, the higher Archæan land rose out of water, and now began the erosion of the elevations and depressions of the north. The waters of the estuary to the south through increasing shallowness would become muddy, and would hold in suspension and transport materials washed from the Archæan hills, while these materials through gradual settling would form the argillaceous soil.

The gravel terraces found in various portions of eastern Pennsylvania, through the labors of the Second Geological Survey, causes Professor Lesley to draw the conclusion that the sea level stood even 1000 feet higher during the Champlain than now. Similar observations in New Jersey by Professor Cook point to a rise of the sea equal to 900 feet. As far as Delaware is concerned, we have direct evidence of a rise of at least 330 feet; but as the evidence was obtained from stratified materials at the highest altitudes in the State, it may be possible that the rise in sea level was as great as inferred by Professor Lesley.

Delaware College, April 2, 1883.

ART. XLVII.—*On the Western discharge of the flooded Connecticut, or that through the Farmington Valley to New Haven Bay;* by JAMES D. DANA.

THE discussion with regard to the flooded Connecticut requires for its completion a revision of the facts with respect to the Farmington valley discharge, presented in my paper of 1875.* It was there shown that the height of the flood from Northampton southward, as indicated by the terraces, was great enough for the waters to have passed the Hampton "divide" between Northampton and Westfield, and the Southwick, between Westfield and the Farmington valley; that they had a height of about 270 feet above mean tide at Simsbury (130 feet above low water in the river), and 223 feet at Southington (85 above low water); and that, from this latter place, while the rapidly

* On the Overflows of the flooded Connecticut, III, x, 438.

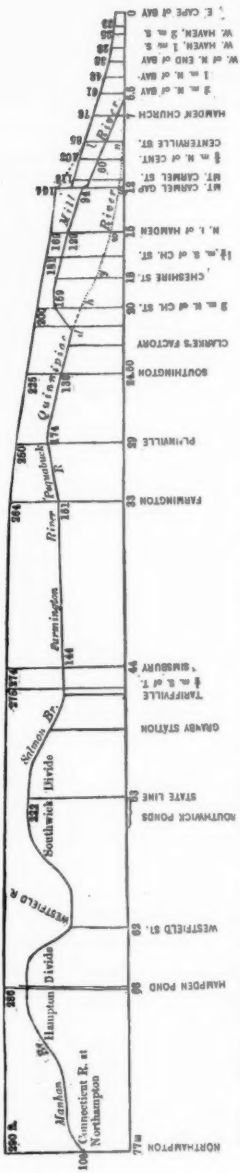
descending Quinnipiac valley gave the most obvious way for the waters to New Haven Bay and Long Island Sound (the mean pitch in the sixteen miles being over nine feet a mile), the level over the Cheshire region and along Mill River was low enough to have afforded a shallower passage-way, and one more directly southward, to the same bay. The Quinnipiac River where the stream turns eastward to leave the Farmington Valley, below Hough's Mills, is at the present time only 100 feet above mean tide, there being a fall of nearly forty feet from Southington; while the head of Mill River in Cheshire, about three miles distant to the southwest, is fifty-five to sixty feet higher; and hence the Quinnipiac was supposed at the time to have taken the most of the waters if not all.

The map of the Connecticut River region, in vol. xxiii, Plate 2 (1882), shows the country and its streams from Northampton along the Farmington Valley and the Quinnipiac and Mill Rivers to New Haven. For the convenience of the reader, the map of the two regions which was published in the paper of 1875 is reproduced as Plate 5 in this volume.

In order to complete a profile of the flood, it became necessary to make new measurements, and also to settle the rival claims of the two streams, the Mill and the Quinnipiac. Unexpectedly little Mill River was proved to have taken all the waters of the Farmington valley when the flood was at its height.

This fact was proved by (1) the continuation of the high terrace of the Southington region over the Cheshire region, along Mill River as well as the Quinnipiac, in spite of the lower position and offers of drainage of the Quinnipiac water-way; (2) the high water level (164 feet) indicated on the Mill River valley south of Cheshire at the Mount Carmel gap; (3) the cobble-stone coarseness of a large part of the stratified valley deposits from Southington southward over the Cheshire region and thence all the way down Mill River valley to New Haven Bay; and then, in contrast with these evidences of high and violent flood along the Mill River route, (4) the very low terrace on the Quinnipiac, as it enters the Meriden valley above Hanover Pond, and (5) the generally sandy nature of the terrace deposits in this part and to the southward along through Wallingford where the sands make barren sand-fields, and beyond to New Haven Bay.

It is plain that the Quinnipiac channel was closed by a dam, probably an ice-dam. The river now leaves the Farmington valley by a gorge that goes eastward through high sandstone hills, and after more than a mile in the gorge or cañon enters the Meriden valley. The gorge was easy of obstruction by



Section of the overflow flood of the Connecticut from Northampton to New Haven.: the lower line, mean-tide level; the middle line, low-water level in the streams over the land that was covered by the flood; the upper line, the upper-terrace level and approximate height of flood. *d*, Hough's mills; *h*, head of Hanover Pond; *y*, Yalesville; *w*, Wallingford; *q*, Quinnipiac Factory; *n*, North Haven.

floating ice, and so the river lost its head. Below the gorge it had to begin anew, with waters from slopes about the latter region, receiving from its former source only what leaks in the dam let through, and hence the terrace also began anew, and was necessarily small. On the other hand to the west of the obstructed gorge, the Farmington flood kept on a straight course to Long Island Sound.

The accompanying profile of the river-flood from Northampton by the Farmington and Mill River valleys to New Haven exhibits the facts to the eye—though with a large exaggeration (nearly 160 times) in the height as compared with the length, an inch horizontal corresponding to twelve miles, and the vertical to 400 feet. The *upper line* shows the height, along the route, of the upper terrace, and thereby approximately that of the flood; starting at 290 feet above mean tide about Northampton, it passed the "divides" with a depth of more than fifty feet and ended at New Haven Bay with a height of about twenty-five feet above present mean tide. The *line next below* is that of low water in the streams. The *lowest* line is that of existing mean tide level; the figures under it give the distances measured along the valley from the east or Light-house Cape of New Haven Bay; and the lettering below, the names of the principal places along the

route where the observations registered were made, with their distances from this cape.*

I. *Section from Northampton along the Farmington, Quinnipiac, and Mill Rivers to New Haven and Long Island Sound.*

	Distance from Sound in miles.	Upper terrace above mean tide.	Low river level above mean tide.	Upper terrace above low river level.
Northampton	77	290	108	182
Hampden Pond	68	286		
Hampton Pl'n ("divide")	64	[249–256]	231	
Westfield	62		122·4	
½m. S. of Tariffville	45·5	275	143·5	131·5
Simsbury	44	274	144	130
Farmington	33	264	151	110
Plainville	29	250	174	76
SOUTHINGTON	24·50	225	138	87
2m. N. of Cheshire St.	20	200	159	41 to W.† / 104 to E.
1½ m. S. of Cheshire St.	16·50	181	142	39
N. line of Hamden	15	169	129	40
Mt. Carmel gap	12	164	94·5 to 82·5	69·5
Mt. Carmel Station	11·50	118·5		36
¾m. N. of Centerville	10	103	60	43
Centerville Station	8·75	88	38	47
Hamden M. E. Church	7	76		50?
2m. N. of N. H. Bay	5·5	61	tide level	
1m. N. of N. H. Bay	4·5	48		
W. of N. end of Bay (N.)	3·5	38		
W. Haven, 1m. S. of N. end of Bay	2·5	28		
W. Haven, 2m. S. of N. end of Bay	1·5	25		
W. Haven, 2¾m. S. of N. end of Bay	1·0	23		
Lighthouse Point E. Cape of Bay	0			

* The height of the terrace at Hampden Pond is from a valuable paper by Mr. J. S. Diller, published in this Journal in 1877, giving careful measurements of the terraces about Westfield and the "divides" north and south. He states that on Westfield River, sixteen miles west of the village, the highest river terrace is 289 feet above sea-level; and that, allowing for the most probable slope in the stream, the height over Westville village is probably not less than 280 feet. (This Journal, III, xiii (1877), 262.)

The heights of the terraces south are from my measurements, for which I used as a base the levels of the New Haven and Northampton railroad, received from the engineer of the road. These levels above mean tide are as follows: at Mt. Carmel Station and Gap, 132 feet; at N. line of Hamden, 135; Cheshire Station, 165; 2 m. N. of ibid., 163; Hitchcock's, 164·5; Southington, 145·76; Plainville, 187·5; Farmington, 241; Allen's Station, 277; Avon, 201; Simsbury, 164·25; surface of Southwick Ponds, 222·11; surface of Hampden Pond, 248·27.

† "To W." signifies above the level of low water on the Cheshire or *western* side, and "to E." above the same on the Quinnipiac or *eastern* side, just below Hough's mills.

The heights are also given in the preceding table, in which the first column contains the distances from the east or Light-house Cape of New Haven Bay; the *second*, the heights of the upper terrace; the *third*, those of low-river levels, above mean tide; and the *fourth*, the height of the upper terrace above the low-river levels.

The above profile shows also, by means of a dotted line (*d*, *n*) the descent by the course of the Quinnipiac valley. On this stream tide-level is reached at North Haven.

A second table is here added, to present in figures the heights of the terrace-deposits and river from Southington, southeastward and southward, by this latter route.

II. *Section from Southington along the Quinnipiac to Fair Haven (E. of New Haven).**

	Distance from Sound (northings) in miles.	Upper terrace above mean tide.	Low river level above mean tide.	Upper terrace above low river level.
SOUTHINGTON	25·25	225	138	87
1·6 m. S. of Southington, at Atwater's factory	23·60	207	129	78
2·05m. S. of Southington, at Clarke's factory	23·20		120	
½m. N. of Hough's mills	20·75	200	102	98
Hough's mills below dam	20·25	200	96–95	104–105
Head of Hanover Pond	19·75	105	86	19
Foot of Hanover dam	19·75	105	69	36
Ab. Yalesville, Sanford's factory	18·33	96	52·5	43·5
Yalesville, Parker's fact.	17·67	93	49	44
Wallingford	15	76	13	63
Quinnipiac factory	13·25	68	5	63
				Ab. mean tide.
North Haven	10·25	60	0	60
½m. N. of Montowese R. R. station	7·75	52	0	52
Junction Hartford and Air Line R. R.	5	49	0	47
Fair Haven R. R. and Perkins St. crossing	4·5	43	0	43
E. Cape of Bay	0			

* The heights of the terraces here given were obtained by leveling from the surfaces of the mill-ponds as a base, the heights of the mill-ponds having been determined from the heights of the dams and the fall of the river between them, obligingly obtained for me by Mr. S. C. Pierson, Civil Engineer at Meriden. The heights of low water are heights to the base of the dams. The heights of these dams are as follows, commencing to the south: the Quinnipiac, on the south boundary of Wallingford, 6 feet; the lower dam at Wallingford (Wallace, Simpson & Co.), 10 feet, the upper, or Community dam, 8 feet; below Yalesville (A. J. Mix's), 10; at Yalesville (Parker's), 10; near Yalesville R. R. station (Sanford), 7; Hanover, 17; Oregon dam (in the gorge between Hanover Pond and Hough's mills, but now destroyed), 6; Hough's mills, 6 feet. Hanover Pond was proved by Mr. Pierson, by leveling from Meriden, to have a height above mean tide of 86 feet, the height of the track of the railroad at Meriden station being 124·63 feet.

The profile and the tables with the other observed facts make manifest:

First. The fact of the Quinnipiac dam, as already explained; the *first* table showing a gradual decline in the heights of the upper-terrace level from Southington through Cheshire; and the *second*, the continuation of the high-level Quinnipiac terrace of Southington to Hough's Mills, or 4½ miles, where the terrace has a height of 200 feet and is one and the same with that of Mill River; then a drop down of 95 feet, the terrace just above the head of Hanover Pond having a height of only 105 feet above mean tide, and but 19 feet above low water in the stream.*

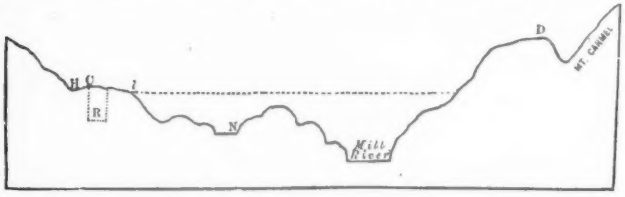
(2.) *Secondly, the existence of a dam at the Mt. Carmel gap and of a sluice-way at its western angle.*—The water-level at the gap, as the profile and tables exhibit, was at least 164 feet above mean tide. From this level there was an abrupt plunge or water-fall, of about 45 feet; for the highest terrace of the flat region directly south is but 118 to 118½ feet, which terrace bears evidence of being the upper in the valley, in that it is continued on as the upper, with gradual slope, to New Haven Bay. The water-fall is indicated in the section, page 442, under the number 164.

The height of the terrace two miles north of the gap is some indication as to flood-level at the gap. But direct evidence is afforded by deposits of very coarse gravel, partly cross-bedded, near the top and under the lea of the western trap ledge of the gap; and also (2) by the continuation of these deposits southward, many of the stones of which for the first mile are one to three feet in diameter, all well smoothed and *none scratched;* and (3) by the existence of remains of a great well-smoothed trough or sluice-way, about 30 feet wide, in the sandstone, which was the work evidently of a violent torrent, several long oblique recesses on its sides, one to three feet broad, being marks of its *revolving* flow; the smoothed surfaces are nowhere scratched, and in this and other ways show that they are not of glacier origin.

The accompanying figure is a profile of the gap, with the height exaggerated only two times. Mt. Carmel (on the east) is an east-and-west ridge, chiefly of trap, 739 feet in greatest height above mean tide. It is the eastern portion of a range

* Going southward from Hanover Pond (southwest of Meriden), the terraces of the Quinnipiac increase in height and become between Wallingford and Fair Haven 40 to 52 feet; this increase was due to tributary waters from the direction of Meriden, and the divide between Hartford and Meriden. In my paper of 1875 I point out the fact that the Connecticut flood waters overtopped this divide. The divide has a height of 185 feet above mean tide, which was 20 or 25 feet below the level of the flood at Hartford; and the terrace topping the divide has a height of about 20 feet.

of trap and sandstone which continues westward to the West Rock trap range. The gap is about 250 yards wide; but it is



partly obstructed by ledges, and Mill River occupies only 100 feet of its breadth. The waters of the sluice-way flowed out (at H) west of the summit of the western of these ledges (C); the lowest level over which at H is now 164 feet. The stratified gravel referred to as under the lea of this ledge (visible from the railroad cut R) has a height of about 152 feet; and the upper limit now visible of the excavated trough or sluice-way near the Mt. Carmel station, half a mile south of the gap, has a height of 145 feet. This trough or sluice-way in the sandstone was uncovered in grading for a new lay-out of the railroad, it offering the lowest level for the track. It can be traced along the course of the railroad for 200 yards below the station; it then passes to the westward of the road and becomes the head of a partly cobble-stone paved valley whose stream joins Mill River at Centreville (see section). The sluice-way torrent must finally have worn away part of the east side of the trough and so made a passage into Mill River valley. The height of the trap at D above mean tide is about 240 feet.

(3.) *The slope of the flood-level was widely different above and below Farmington.*—The slope of the terrace (or of flood-level) for the first 33 miles, that is, from Northampton to Simsbury (*Sb* on plate 5) was only 6 *inches* a mile; and for the first 44 miles, or to Farmington, about 7 *inches*: while southward, from Farmington to a point 2 miles north of Cheshire, where the high land of Cheshire begins, it was about 5 *feet* a mile; from the latter place to the Mt. Carmel gap, about the same; and from Mt. Carmel village to New Haven Bay, 10 *feet* a mile. A reason for this change in slope at Farmington exists in the fact that the flooded Farmington River here entered the valley from an extensive region to the northwest, and the Pequabuck added waters from the west; the two draining a high portion of western New England about 200 square miles in area. The flood consequently received its greatest accessions at this point; and the waters were so rapidly supplied that the slope northward was diminished and that southward increased. On the *west* side of the valley to the north of Farmington station, the

upper terrace is well displayed, and especially along by Simsbury and for a mile and more to the north, where it is 130 feet above low water in the river and quite wide. But on the *east* side of the valley the terrace above Farmington is for the most small, no large stream, capable of affording transported material, flowing from that direction because of the nearness of the trap range.

Further, the terrace deposits are greatly coarser south of the Farmington River entrance than to the north of it. To the north they are chiefly of sand with fine or coarsish gravel above; but near the Farmington station and south of it through Southington and beyond, the deposits are remarkable for their coarseness, as above stated.

(4.) *A great change in the old hydraulic conditions.*—Before the era of the flood the drainage south of Northampton, supposing the land to have had nearly its modern slopes, was as follows: for a dozen miles *northward;* then *eastward*, in Westfield river; for the next three miles, the first half *northward* and the second *southward;* then for 17 miles *northward*, by the Farmington River and the Pequabuck; finally, for the rest of the distance to New Haven, 25 miles, *southward*, excepting a break of two miles between the Quinnipiac and the head of Mill River. But, in the era of the flood, this whole uneven region of many slopes, was under one continuously sloping water-plane, having a fall, if reckoned on the basis of the present slope of the land, of 290 feet in 77 miles. The northward-flowing streams and the streams at equilibrium as to erosion and deposition, or at "base level," if any there were, were merged with the southward flowing streams into one great southward hurrying flood, the depth exceeding 120 feet at maximum height and 40 feet where shallowest. It is an example, though on an extreme scale, of the kind of change over a region which a modern flood may produce in hydraulic conditions and in the activity of fluvial forces.

The flood produced other effects over the New Haven region south of the Mt. Carmel gap, which are of much geological interest. These will make the subject of another article.

A few words only are here added as to the bearing of the facts reviewed on the question with regard to *the slope of the land in the era of the flood.*

In my paper on "flood of the Connecticut River valley," in volume xxiii of this Journal (1882), it is apparently proved that the southward slope of the land was much less during the flood than now—the calculated mean diminution from the Sound to Springfield being one foot a mile, and from Springfield to Haverhill 2½ feet a mile. Hence we should expect to find evidence of some corresponding difference of slope

to the westward of the Connecticut over the Farmington valley. But it follows from the facts presented that the diminution in slope between Farmington and Northampton *could not have been* 1 *foot a mile without producing a current northward*, and so making Northampton the place of discharge instead of outflow; for it would have given a mean slope in that direction of 5 to 6 inches a mile. Mr. Diller, in his paper on the Westfield region, mentions as evidence of a *southward* flow from Northampton that the terrace material over the Hampton "divide" diminishes in coarseness southward, and that it contains a great abundance of fragments or pebbles of trap which had their only source to the northward in the northwest angle of Mount Tom. Moreover, since the fall from Northampton to New Haven at maximum flood was in any case over 200 feet, it is impossible, without a most improbable inflow, that the waters should have been so piled up at Farmington as to flow in opposite directions. We have to conclude, therefore, that the diminution in slope southward must have been less than 7 inches a mile. No clay deposits are known to occur in the Farmington terrace deposits, and no other evidence of lacustrine conditions.

South of Farmington the coarse deposits may have been made with the slope diminished a foot or more.

In the Meriden valley, where the terrace formation consists mainly of sand, the present pitch of the terrace-level is much too great for such depositions. From Hanover Pond to North Haven the mean slope, according to Table II, is $4\frac{1}{2}$ feet a mile; and about 4 feet, from the same point to Fair Haven.

ART. LXVIII.—*Results of some experiments made to determine the variations in length of certain bars at the temperature of melting ice;* by R. S. WOODWARD, E. S. WHEELER, A. R. FLINT and W. VOIGT.

THE precision attained of late in comparisons of standards of length, and in geodetic work dependent on such standards, has rendered the question whether a given bar can have differing lengths at the same temperature an important one. In order to obtain some data bearing directly on this question the authors of this paper have undertaken on their own account a series of experiments with bars of various metals.

For the purpose of making these experiments the following apparatus has been provided:

1st. Two micrometer-microscopes designated F and W respectively. The optical work on these is by Bausch and Lomb of Rochester, N. Y., and the micrometers and stands were made

by L. Wohnlich of Detroit, Mich. The magnifying power of each microscope as used in the experiments is about thirty diameters. They are provided with leveling and clamp screws, can be revolved completely in azimuth (thus permitting the determination of the lines of collimation) and have detached levels with which they may be made vertical. They are mounted one meter apart on an oak beam. This beam is $1{\cdot}8^{m}$ long, 26^{cm} wide and 5^{cm} deep. Its ends are supported on heavy stone piers about 1^{m} high

2d. Two steel meter-bars. They are $1{\cdot}04^{m}$ long and 16^{mm} square in cross-section. They were made from ordinary Jessup steel in the summer of 1881. The upper half of either bar at each end is cut away for a distance of 3^{cm}, so that the graduations cross the neutral axis. They were graduated and their lengths and expansions were determined by Professor W. A. Rogers of Cambridge, Mass. They are designated S_1 and S_2 respectively.

3d. One zinc bar, which is $1{\cdot}03^{m}$ long and 27^{mm} square in cross-section. It was cast in the summer of 1881. The ordinary zinc of commerce was used, and the bar was cast in a vertical position. About $0{\cdot}2^{m}$ of the upper end of the casting was cut off. The top half of the bar at each end is cut away for a distance of 2^{cm}, so that the graduations cross the neutral axis. This bar was also graduated and its length and expansion were determined by Professor Rogers. It is designated Z_1.

4th. Two glass meters. They are of French plate, $1{\cdot}02^{m}$ long, 8^{mm} thick and 51^{mm} deep. Half the depth of either bar at each end is cut away for a distance of 2^{cm}, and the graduations cross the neutral axis. They are designated G_1 and G_2 respectively.

5th. One copper meter. It was cast in February, 1883, and is $1{\cdot}02^{m}$ long, 20^{mm} wide and 22^{mm} deep. Its graduations cross the neutral axis. It is designated C_1.

6th. One brass meter. It was cast in February, 1883, and is composed of ten parts of copper to three of zinc. It is of the same form and dimensions as the copper meter. It is designated B_1.

Comparisons are made in the following manner:

The bars to be compared are each placed in a wooden box $1{\cdot}1^{m}$ long, $0{\cdot}1^{m}$ wide and $0{\cdot}1^{m}$ deep. The bars are supported in their boxes at two points distant about one-fourth and three-fourths the length of the bar from either end. The boxes are filled with finely powdered ice so as to completely surround the bars except at small spaces near the graduations. The boxes are placed on a shelf under the microscopes. Each box has three leveling screws which rest on plates of glass, so that the bars may be easily adjusted to any requisite position. The

graduated surfaces of the bars are brought into a horizontal plane within 1′ by means of a long striding level. The microscopes are focused on the graduations at the ends of a level bar, made vertical within 1′ and their readings on the lines of collimation determined. Micrometer readings are then made on the bars alternately, these readings being near the lines of collimation. The values of the micrometer screws are determined at intervals by reading on spaces of known value. No account has been taken of the periodic errors of the screws, since an investigation has shown these errors to be insignificant in comparison with other errors incident to the experiments.

The plan adopted in making the experiments is this: Taking one of the steel bars as a standard, several sets of comparisons are made with another bar. The latter bar is then put into water and left there while the water is heated gradually to the boiling point. It is then taken out of the water and cooled down gradually to the melting point of ice, when several sets of comparisons are again made with the standard. Afterwards the bar is cooled gradually to $-6°$ or $-8°$ F., warmed gradually to the melting point of ice and again compared with the standard.

The following table gives the comparisons of the steel meter S_1 and the zinc meter Z_1, both bars while under comparison being closely packed in melting ice. The micrometer readings are expressed in revolutions of the screws. One revolution of $F = 92{\cdot}1^{\mu}$ and one revolution of $W = 95{\cdot}3^{\mu}$, the symbol μ meaning *microns* or millionths of a meter. The revolutions increase in the direction F—W; so that if F_1 and W_1 are the readings on Z_1 and F_2 and W_2 the readings on S_1, we have from these readings

$$Z_1 - S_1 = (F_1 - F_2)\, 92{\cdot}1^{\mu} - (W_1 - W_2)\, 95{\cdot}3^{\mu}$$

Comparisons of S_1 *and* Z_1 *at the temperature of melting ice.*

Date.	Time.	Bar.	Micro-readings. F	Micro-readings. W	Observer.	Remarks.
1883.						
Jan. 28	11.45A.M.	S_1	28·059	24·462	A. R. F.	Both bars packed in ice ten minutes before readings on them were made.
			058	462	and	
			061	463	R. S. W.	
			060	458		
	51	Z_1	28·044	24·371		
			050	374		
			039	370		
			048	374		
	56	S_1	28·010	24·387		
			27·998	334		
			994	339		
			999	341		
	59	Z_1	27·943	24·260		
			950	262		
			939	257		
			950	257		
	12.04P.M.	S_1	27·697	24·243	E. S. W.	
			701	251	and	
			680	238	W. V.	
			688	259		
	09	Z_1	27·861	24·190		
			861	183		
			857	176		
			848	176		
	13	S_1	27·690	24·189		
			686	186		
			687	189		
			688	186		
	17	Z_1	27·689	24·018		
			692	020		
			682	018		
			679	020		
Jan. 29	8.27	S_1	28·112	25·088	A. R. F.	Both bars fully packed in ice at 8.10 P. M.
	31	Z_1	153	031	and	
	35	S_1	165	134	E. S. W.	Temperature of comparing-room 56° F.
	38	Z_1	002	24·855		
	42	S_1	010	949		
	45	Z_1	27·988	846		
	48	S_1	935	909		
	51	Z_1	28·020	913		
	55	S_1	27·918	905		
	58	Z_1	892	782		
	9.01	S_1	998	962		
Jan. 30	7.23	S_1	28·208	121	E. S. W.	Both bars were fully covered with ice at 7.05 P. M.
	30	Z_1	313	099		
	36	S_1	273	164		Temperature in comparing-room 55° F.
	40	Z_1	262	066		
	45	S_1	124	039	R. S. W.	
	49	Z_1	430	241		
	55	S_1	161	102		
	59	Z_1	509	332		
	8.03	S_1	034	23·971	E. S. W.	
	06	Z_1	161	24·010		
	12	S_1	27·808	23·822	R. S. W.	
	27	Z_1	890	771		

Comparisons of S_1 *and* Z_1 *at the temperature of melting ice—con'd.*

Date.	Time.	Bar.	Micro-readings. F	Micro-readings. W	Observer.	Remarks.
1883.						
Jan. 31	7.57 P.M.	S_1	27·926	23·830	E. S. W.	Steel meter was fully packed in ice at 6.55 P. M., and zinc meter at 7·08.
	8.05	Z_1	915	700		
	14	S_1	749	695		
	17	Z_1	556	411		The temperature of the ice (granulated snow brought in from out doors at 6.55 P. M.) was found to be below the melting point. Hence both boxes were placed near a furnace fire until the snow would not adhere to the bars. Temperature of comparing-room 50° F.
	22	S_1	716	660		
	26	Z_1	658	504		
	30	S_1	28·272	24·217	R. S. W.	
	35	Z_1	368	232		
	40	S_1	361	324		
	50	Z_1	321	177		
	55	S_1	064	064		
	59	Z_1	077	23·956		
	9.02	S_1	27·997	994		At 4.30 P.M. Z_1 was put inside and raised about ¾ inch from bottom of tin receiver. The latter was put on a stove and filled with water at temperature 41° F. Water was 1 inch deep over bar. Fire was started under receiver at 4.50. Bar was heated to about 208° F. and remained at that temperature about 15 minutes.
Feb. 2	8.55	S_1	28·800	24·223	E. S. W.	
	9.02	Z_1	29·486	23·310		
	09	S_1	27·940	418		
	13	Z_1	28·661	22·541		
	24	S_1	208	23·680	R. S. W.	
	27	Z_1	29·069	22·950		Z_1 was taken out of water at 8.10 and packed in ice at 8.45.
	30	S_1	27·909	23·395		
	36	Z_1	28·475	22·406		S_1 was packed in ice at 8.30.
Feb. 3	11.09 A.M.	S_1	27·748	23·128		Both bars remained packed in ice during night of Feb. 2d and 3d. At 8.30 A. M. they were repacked with additional ice and remained so until readings began.
	17	Z_1	29·768	870		
	22	Z_1	410	508		
	26	S_1	28·622	993		
	30	S_1	607	970		
	36	Z_1	29·068	197		
	40	Z_1	28 918	059		
	45	S_1	100	490		
	49	S_1	27·850	252		
	55	Z_1	28·463	22·619		
Feb. 3	7.29 P.M.	S_1	28·361	23·979	E. S. W.	Both bars have been kept packed in ice since 11.55 A. M.
	38	Z_1	858	300		
	44	Z_1	29·123	552		
	49	S_1	28·502	24·145		
	58	S_1	837	472	R. S. W.	
	8.03	Z_1	29·474	23·910		
	10	Z_1	691	24·176		
	15	S_1	009	664		
	20	S_1	28·748	436		
	23	Z_1	29·287	23·749		
Feb. 4	10.53 A.M.	S_1	28·268	24·115	E. S. W.	Both bars have remained in ice all night.
	11.01	Z_1	788	23·552		
	06	Z_1	29·229	970		
	09	S_1	28·178	24·024		
	13	S_1	474	290	R. S. W.	
	17	Z_1	834	23·556		
	24	Z_1	29·041	739		
	27	S_1	28·358	24·189		
	32	S_1	567	405		
	35	Z_1	29·028	23·760		
Feb. 5	8.04 P.M.	Z_1	142	970		Zinc bar has remained in melting ice constantly.
	07	S_1	28·532	24·460		
	11	S_1	619	540		
	14	Z_1	801	23·662		

Comparisons of S_1 *and* Z_1 *at the temperature of melting ice—con'd.*

Date.	Time.	Bar.	Micro-readings. F	Micro-readings. W	Observer.	Remarks.
1883.						
Feb. 5	8.18 P.M.	Z_1	29·135	23·980	E. S. W.	Zinc bar has remained in melting ice constantly.
	21	S_1	28·406	24·339		
	24	S_1	780	702		
	29	Z_1	29·196	070		
	34	Z_1	383	268		
	37	S_1	198	25·118		
	46	S_1	067	005	R. S. W.	
	50	Z_1	464	24·280		
	57	Z_1	345	210		
	9.00	S_1	28·802	752		
Feb. 6	7.23	S_1	211	23·866	E. S. W.	Zinc bar has remained packed in ice since last evening.
	35	Z_1	618	221		
	45	Z_1	29·081	656		Steel bar was packed in ice about 6.45 P. M.
	52	S_1	27·966	634		
	8.03	S_1	28·004	685	R. S. W.	Temperature of air in comparing-room 44° F.
	11	Z_1	517	135		
	18	Z_1	435	069		
	21	S_1	27·710	433		
Feb. 7	7.46	S_1	28·533	24·214	E. S. W.	Both bars have been unpacked and exposed to the air of the comparing-room during the past 24 hours.
	8.03	Z_1	29·218	23·782		
	10	Z_1	28·618	229		
	17	S_1	27·994	646		
	23	S_1	28·369	24·019	R. S. W.	Temperature of air in comparing-room 44° F.
	26	Z_1	815	23·516		
	35	Z_1	865	565		Bars were packed in ice about 7.20 P. M.
	40	S_1	446	24·119		
	43	S_1	753	425	E. S. W.	
	47	Z_1	29·404	062		
Feb. 8	9.28	S_1	28·350	110	R. S. W.	Both bars have been out of the ice during the past 24 hours.
	35	Z_1	727	23·428		
	38	Z_1	764	453		They were packed in ice about 8.00 P. M.
	42	S_1	260	979		
	45	S_1	388	24·111		Temperature of air in comparing-room 45° F.
	48	Z_1	952	23·610		
	52	Z_1	967	629		
	55	S_1	444	24·148		
Feb. 9	5.18	S_1	438	220	E. S. W.	Both bars have been out of the ice since 10.00 P. M. Feb. 8th.
	23	Z_1	29·098	23·778		
	28	Z_1	176	861		Both bars were taken out of the ice at 5.55 P. M.
	32	S_1	28·626	24·394		
	38	S_1	717	504	R. S. W.	
	40	Z_1	29·420	114		
	48	Z_1	454	163		
	50	S_1	730	488		
Feb. 10	11.41 A.M.	Z_1	28·330	249		At 9.30 P. M. Feb. 9th, the zinc bar was placed in its receiver, taken out doors and left out all night. At 6.45 A. M. Feb. 10th, a thermometer which had lain alongside the zinc bar during the night read −8° F. At 7.30 the zinc bar was packed in granulated snow and brought into the comparing-room in which the temperature of the air was 45° F.
	45	S_1	631	284		
	50	S_1	341	016		
	55	Z_1	407	308		
	12.01	Z_1	372	287		
	04	S_1	498	181		
	09	S_1	796	494		
	14	Z_1	744	639		The steel bar was packed in ice about 9.00 A. M.
	19	Z_1	410	309	E. S. W.	
	21	S_1	410	101		

Comparisons of S_1 *and* Z_1 *at the temperature of melting ice—con'd.*

Date.	Time.	Bar.	Micro-readings. F	Micro-readings. W	Observer.	Remarks.
1883.						
Feb. 10	7.59 P. M.	S_1	28·374	23·979	E. S. W.	Both bars have remained packed in ice since 12.21 P. M.
	8.12	Z_1	345	24·126		
	21	Z_1	028	23·825		
	25	S_1	052	649		
	35	S_1	275	901	R. S. W.	
	38	Z_1	684	24·507		
	50	Z_1	398	212		
	54	S_1	564	179		
Feb. 11	10.42 AM	S_1	526	24·192	E. S. W.	Zinc meter has remained packed in ice during past night.
	49	Z_1	591	460		
	58	Z_1	231	100		Steel bar was packed in ice about 10.00 A. M.
	11.03	S_1	283	23·928		
	08	S_1	486	24·139	R. S. W.	
	13	Z_1	577	448		
	23	Z_1	859	717		
	26	S_1	833	493		
Feb. 12	8.00 P. M.	S_1	126	090		Both bars were packed in ice at 7.30 P. M.
	03	Z_1	006	013		
	08	Z_1	259	267		
	11	S_1	273	242		
	13	S_1	122	080	E. S. W.	
	15	Z_1	208	248		
	21	Z_1	208	258		
	24	S_1	074	063		
Feb. 13	8.19	S_1	272	345		The zinc bar was taken out of the ice at 8.30 P. M. Feb. 12th and left in comparing-room until 4.00 P. M. to-day. It was then taken into a room where the temperature was about 70° F. and remained there until 7.45 P. M. It was fully packed in ice at 7.55. Temperature of air in comparing-room 50° F. Steel bar was fully packed in ice at 8.00 P. M.
	27	Z_1	270	123		
	36	Z_1	27·990	23·850		
	39	S_1	28·386	24·446		
	42	S_1	429	518	R. S. W.	
	45	Z_1	528	388		
	47	Z_1	534	383		
	50	S_1	340	421		

The foregoing include all the comparisons which have thus far been made of the zinc and steel bars.

The mean differences in length of the two bars for the various sets of comparisons are given in the following table. Their probable errors are derived from the discrepancies between the mean and individual differences resulting from successive comparisons in a set.

Mean differences of Zinc and Steel bars.

Date.	$Z_1 - S_1$	Remarks.
1883.	μ μ	
Jan. 28 A. M.	+ 12·2 ± 2·8	Before heating Z_1.
29 P. M.	+ 9·0 ± 0·5	
30	+ 9·9 ± 0·5	
31	+ 10·4 ± 0·4	
Feb. 2	+ 149·1 ± 0·7	After heating Z_1 to 208° F.
3 A. M.	+ 116·6 ± 0·4	Z_1 remained constantly in melting
3 P. M.	+ 112·3 ± 0·8	ice from 8.45 P. M. Feb. 2d to 8.21
4 A. M.	+ 103 3 ± 0·5	P. M. Feb. 6th.
5 P. M.	+ 100·1 ± 1·0	
6	+ 100·4 ± 0·4	
7	+ 95·3 ± 1·8	
8	+ 98·2 ± 0·5	
9	+ 101·0 ± 0·8	
10 A. M.	− 21·2 ± 0·7	After cooling Z_1 to about −8° F.
10 P. M.	− 18·5 ± 0·5	Z_1 was in melting ice from morn-
11 A. M.	− 20·1 ± 0·4	ing of Feb. 10th to evening of
12 P. M.	− 5·5 ± 0·7	Feb. 11th.
13	+ 21·1 ± 0·2	After heating Z_1 to about 70° F.

As indicated by the probable error of the mean difference, the comparisons of January 28th showed larger residuals than any subsequent set of comparisons. The comparisons of this date were the first made, and some unusual error may have been committed through lack of familiarity with the apparatus, though the observers are not aware that such was the case. Before packing it in ice on January 28th, the zinc bar had been for many months warmer than 32° F.

The close agreement of the mean differences for the first four dates may possibly result from the fact that the temperature of the comparing-room had varied for several days previous to the comparisons but little from 55° F., so that the bar was subjected to essentially the same conditions each day; i. e. just previous to each set of these comparisons Z_1 had fallen from about 55° F. to the temperature of melting ice.

The characteristic results obtained may be stated as follows:

1st. The temperature of the zinc meter was raised to 208° F. and then lowered to the temperature of melting ice. This increased its length at first 139μ over its initial length. The bar was kept constantly in melting ice for four days, during which time it shortened 39μ, leaving it still 90μ longer than its initial length. Exposure to the air of the comparing-room (temperature about 45° F.) during the intervals between comparisons for the three days following, produced no material change in the length of the bar.

2d. The bar was cooled in the open air to about −8° F. and then warmed to the temperature of melting ice. This dimin-

ished its length to 30$^{\mu}$ less than its initial length. The bar was kept constantly in melting ice for one and a half days, during which time no marked change in length occurred; but exposure to the air of the comparing-room for an interval of one day was followed by an increase of 15$^{\mu}$ in the bar's length, leaving it still 15$^{\mu}$ shorter than its initial length.

3d. The bar was exposed to an air temperature of about 70° F. for four hours and then cooled to the temperature of melting ice. This increased its length 26$^{\mu}$ over the length it had on the previous day, leaving it 11$^{\mu}$ longer than its initial length.

4th. The total range in temperature to which the bar was subjected was about 216° F. The total range in length of the bar at the temperature of melting ice was 169$^{\mu}$.

In the comparisons of the steel, copper and brass meters with the steel standard, each bar except the standard was subjected to a temperature-range whose limits were approximately 212° F. and −6° F., the former temperature being secured by means of boiling water and the latter by means of a mixture of snow and salt. For the comparisons of the two steel meters S_1 and S_2 the latter was taken as the standard. For the comparisons of the copper meter C_1 and the brass meter B_1, S_1 was used as a standard. In order to prevent any serious bending of the copper bar it was laid on the steel bar S_2 and kept in contact with the latter throughout the period of the comparisons. The results of the comparisons of these bars are given in the following tables. Each result is a mean derived from four to ten independent comparisons. It will be remembered that differences in length were measured only after the bars under comparison had been for some time closely packed in melting ice.

Differences in Length of the Steel Meters.

Date, 1883.	$S_2 - S_1$	Mean.	Remarks.
	μ	μ	
February 12	+11·0		
" 13	+ 9·6	+ 9·9	Before heating S_1
" 14	+ 9·0		
" 15	+ 9·9		
" 16	+10·1	+10·0	After heating S_1 to near 212° F.
" 18	+ 9·9		
" 23	+ 9·2		
" 25	+12·1		
" 26	+12·1	+10·9	After cooling S_1 to near −6° F.
" 26	+10·4		

Differences in Length of Steel and Copper Meters.

Date, 1883.		$S_1—C_1$	Mean.	Remarks.
		μ		
March	4	+43·7		
"	4	+50·5	μ	
"	5	+45·2	+47·1	Before heating C_1
"	5	+47·5		
"	6	+48·8		
"	7	+45·1		
"	9	+47·4		After heating
"	9	+51·4	+47·9	C_1 to near 212° F.
"	10	+47·7		
"	10	+45·6		
"	11	+47·9	+46·2	After cooling
"	12	+45·6		C_1 to near −6° F.

Differences in Length of Steel and Brass Meters.

Date, 1883.		$S_1—B_1$	Mean.	Remarks.
		μ		
March	10	+40·1		
"	11	+36·7	μ	
"	12	+36·1	+37·2	Before heating B_1
"	13	+36·0		
"	13	+34·0		
"	14	+36·7	+35·8	After heating
"	15	+36·8		B_1 to near 212° F.
"	20	+38·4		
"	21	+41·7	+39·6	After cooling
"	23	+38·6		B_1 to near −6° F.

The probable error of a single difference of length in the above tables may be derived preferably from the formula

$$0{\cdot}6745\sqrt{\frac{[vv]}{m-n}},$$

in which m is the whole number of results, n the number of groups of comparisons and $[vv]$ the sum of the squares of the discrepancies between the mean and individual results for the several groups. Including the results for the glass bars given below, this probable error is found to be $\pm 1^{\mu}{\cdot}3$.

The means of the respective groups of comparisons of the steel, copper and brass meters with the standard, do not differ enough to indicate certainly that any change of length (at the temperature of melting ice) was produced by the heating and cooling process, although the brass bar was apparently lengthened by heating and shortened by cooling it. The difference between the mean results for the brass bar after heating and after cooling it, viz: $3^{\mu}{\cdot}8$, though a measurable quantity is quite within the range which might be inferred from the above probable error.

For the comparisons of the glass meters G_1 and G_2, the steel meter S_1 was used also as a standard, and the same program was followed as with the other bars. By accident, however, G_1 was broken just subsequent to the second set of comparisons after heating it. The results of these comparisons are given in the following tables.

Differences in Length of Steel and Glass Meters.

Date, 1883.	$G_1 - S_1$	Mean.	Remarks.
	μ		
February 20	+154·1		
" 21	+154·9	μ +154·9	Before heating G_1
" 21	+155·8		
" 21	+159·1		After heating
" 22	+158·0	+158·5	G_1 to near 212° F.

Differences in Length of Steel and Glass Meters.

Date, 1883.	$S_1 - G_2$	Mean.	Remarks.
	μ		
March 15	+40·8		
" 16	+43·5	μ	
" 16	+41·3	+41·0	Before heating G_2
" 17	+38·4		
" 17	+38·2		
" 18	+37·8	+38·2	After heating
" 19	+39·3		G_2 to near 212° F.
" 20	+39·4		
" 21	+36·8	+38·1	After cooling
" 23	+38·1		G_2 to near −6° F.

The means of the groups of results before and after heating the glass meters indicate that each bar was slightly lengthened (at the temperature of melting ice) by the heating, the quantity being $3^{\mu}\cdot6$ for G_1 and $2^{\mu}\cdot8$ for G_2. Although these quantities are within the range indicated by their probable errors, the fact that they agree so closely renders it somewhat probable that the heating process did produce a set in each bar. A much larger set might have been expected, as the opinion seems to be quite general that glass after being heated to temperatures as high as 212° F. does not speedily return to the dimensions it had, before being heated, at temperatures lower than 212° F. This opinion, however, appears to be based on experience with mercurial thermometers, in which a change of 0°·5 in the position of the freezing-point is not uncommon after the bulb has been heated to 212° F. Since the coëfficient of the cubical expansion of mercury is about $\frac{1}{10000}$ per degree F., a change of 0°·5 F. in the position of the freezing-point of a thermometer would correspond to a linear change of $\frac{1}{60000}$, or to $16^{\mu}\cdot7$ in the length of a meter. If, as indicated

by our experiments, some kinds of glass possess the property in question only in a very small degree, it would be interesting to know whether the change in the position of the freezing-point so uniformly and frequently so markedly manifested in thermometers is really due wholly to a temporary change in the dimensions of the bulb, and if so what gives to glass used for thermometers this property.

The experiments thus far made are much less numerous and complete than is desirable; and the authors hope they may be able at some future time to make additional experiments with the same and other bars, and also to investigate the properties of glass used for thermometers. Two inferences are suggested, however, by these experiments, viz: 1st, that zinc is not a reliable metal for one of the components of a metallic thermometer, much less for a standard of length; 2d, that bars of steel, copper and brass are not likely to vary in length appreciably at any temperature within the range of temperature to which standards are ordinarily subjected.*

ART. LXIX.—*On Scovillite, a new phosphate of Didymium, Yttrium and other rare earths, from Salisbury, Conn.;* by GEORGE J. BRUSH and SAMUEL L. PENFIELD.

IN October last, Mr. Joseph S. Adam, formerly an assistant in the Sheffield Laboratory, but now chemist of the iron furnaces at Lime Rock, Conn., sent one of us a mineral he had discovered occurring sparingly as an incrustation on some of the iron and manganese ores from the Scoville ore bed in Salisbury, Conn. Mr. Adam found the mineral to be a hydrous phosphate, and sent it to us for further identification.

The specimens which Mr. Adam kindly furnished us for examination show the mineral incrusting limonite and pyrolusite, very much as gibbsite coats the limonite of the Richmond ore bed. The incrustation is one-sixteenth of an inch or less in thickness, and is frequently botryoidal or stalactitic in form. On the cross fracture it presents a radiated fibrous structure. The color is of a pinkish, brownish to yellowish white. It has a silky to vitreous luster on the fracture, but the natural surfaces have a greasy look, and in luster and color, as well as in form of occurrence, the mineral resembles some varieties of chalcedony or smithsonite. Hardness = 3·5. Specific gravity 3·94–4·01.

*The authors desire to acknowledge their indebtedness to Mr. T. Russell and Mr. C. V. Mersereau for the loan of parts of the apparatus owned by them, and to Mr. G. Y. Wisner for assistance rendered in the preparation of the copper and brass bars.

The preliminary examination proved the mineral to be an infusible hydrous phosphate, affording no coloration when treated with cobalt solution, but when fused with salt of phosphorus and borax it gave a remarkable rose-colored bead, both in the oxidizing and reducing flames. The mineral is soluble in hydrochloric and nitric acids. Qualitative analysis showed it to be essentially a hydrous phosphate of the cerium and yttrium metals with a trace of iron and a small amount of carbonic acid. As so few minerals contain these rare earths, and the methods for their separation and determination are frequently attended with difficulty and uncertainty, we have thought proper to give in detail the methods employed in the analyses.

The mineral was dissolved in hydrochloric acid and the metals were precipitated from the acid solution as oxalates. The oxides obtained from igniting this precipitate were easily soluble in dilute acids, giving light rose-colored solutions from which, on addition of a solution of potassium sulphate, a precipitate of the sulphates of the cerium metals was separated. This precipitate, first freed from all traces of the yttrium metals, gave no reaction for cerium when tested by Gibbs's method* with peroxide of lead, but solutions of the oxides examined with the spectroscope showed the absorption bands characteristic of didymium. An acetic solution of the oxides was supersaturated with ammonia, and the precipitate which was formed was filtered off and thoroughly washed; this precipitate, when sprinkled with iodine, gave the characteristic blue coloration due to the presence of lanthanum.†

In the filtrate from the precipitated sulphates of the cerium metals, the yttrium metals were thrown down as oxalates from hot acid solutions. The precipitate had a faint pink color, and when ignited and dissolved in acid the solution showed with the spectroscope the erbium absorption bands. The spark spectrum showed that yttrium was also present.

In the quantitative analyses, owing to the scarcity of pure material, the separate determinations were made on small quantities so as to give chances for repetition or variations in the method if necessary. The analyses were made on the air-dried mineral. It was found that the powdered mineral lost water, but it soon assumed a constant weight when dried at 100° C. The mineral dried at 100° and then ignited in a Bohemian glass tube gave the more firmly combined water which was collected in a chloride of calcium tube and weighed. Carbonic acid was determined by dissolving the mineral in a flask with dilute hydrochloric acid and collecting and weighing the liberated gas in potash bulbs. In analysis II the mineral, after drying at

* W. Gibbs, this Journal, II, xxxvii, 352.

† Fresenius' Qualitative Analysis (Johnson's edition), p. 125.

100°, was directly ignited over the blast lamp, giving a loss of water and carbonic acid agreeing closely with the sum of the separate determinations in analyses I and III. One direct determination of phosphoric acid was made with ammonium molybdate, analysis IV. After filtering off the phosphorus precipitate the bases were precipitated from the filtrate by means of ammonia, and after the separation of traces of molybdenum and the cerium metals a volumetric determination of iron was obtained.

For the separation of phosphoric acid from the bases the following method was adopted. The mineral being easily soluble in hydrochloric acid, a solution containing little free acid was obtained; this was poured into about 500 c.c. of boiling water containing enough ammonium oxalate in solution to unite with the bases to form oxalates; the separation of a crystalline precipitate of the oxalates soon took place, which was quite free from phosphoric acid and contained all but traces of the bases; the solution and precipitate were allowed to stand over night, then filtered and washed with hot water. The filtrate was evaporated to small bulk and the remaining oxide precipitated along with some phosphoric acid from the hot solution by means of ammonia. This small precipitate was collected and weighed and the oxides separated from the phosphoric acid by means of mercurous nitrate.* From the filtrates the phosphoric acid was precipitated with magnesia mixture. The precipitates of the oxalates were brought together, strongly ignited over the blast lamp and weighed. After weighing they were dissolved in sulphuric acid and to the solution enough hot concentrated potassium sulphate solution was added to give when cold a saturated solution and thus cause the precipitation of the lanthanum and didymium. These metals were not separated, but an attempt was made to determine the quantity of the didymium by igniting the nitrates obtained from a weighed quantity of the oxides in a current of oxygen, which should give, according to B. Brauner,† the higher oxide of didymium Di_2O_5 and La_2O_5, and from the gain in weight of the oxide it was hoped that the quantity of didymium could be calculated. The results however were unsatisfactory, the gain in four trials being 7·5, 8·6, 6·9 and 8·2 per cent of the oxide employed. Pure didymium oxide with atomic weight 146·58 would require an increase of 9·38 per cent. A determination of the combined atomic weight of these oxides, made by converting a known weight of oxide into anhydrous sulphate gave 142·6, which was the number used in calculating the results of the analyses.

* Rose, Quantitative Analyse, p. 524.

† Ber. der Deutsch. Chem. Gesellsch., xv, 115.

The filtrate from the precipitated sulphates of the cerium metals was treated with ammonium oxalate to separate the yttrium metals. The precipitate of the latter being impure, it was in all cases redissolved and reprecipitated, and after ignition weighed as oxides. No attempt was made to separate yttrium from the erbium. A determination of the combined atomic weight of the two oxides, made by converting a known weight of oxide into anhydrous sulphate, gave 115, indicating that the proportion of yttrium is about twice that of the erbium. Analyses I, II, III and IV were made on about ·5 gram; analysis V on about a gram. The results are as follows:

	I.	II.	III.	IV.	V.	Mean.	Ratio.	
P_2O_5		24·96	25·03	25·00	24·77	24·94	·1756	
(Y_2O_3, Er_2O_3)		8·34	8·67		8·51	8·51	·0306	·1977
(La_2O_3, Di_2O_3)		55·30	54·87		55·34	55·17	·1656	
Fe_2O_3				·24	·26	·25	·0015	
Combined H_2O	5·88					5·88	·3267	
$CO_2 + H_2O$		9·36						
H_2O lost at 100°		1·50	1·49			1·49	·0828	
CO_2			3·59			3·59	·0814	
						99·83		

In discussing these analyses the question at once arises as to whether the carbonic acid found is an essential constituent of the mineral. The carbonate does not appear to bear any simple relation to the phosphate, and we have thought best to regard it as due to an admixture of lanthanite $(La, Di)_2(CO_3)_3 9H_2O$. Regarding the water given off at 100° C. as representing only three molecules in the above formula, the remaining six going off at a higher temperature, we have the following ratio calculated with CO_2 as a basis:

$$R_2O_3 : 3CO_2 : 9H_2O = ·0271 : ·0814 : ·2456 = 1 : 3 : 9·06$$

and there remains, after deducting the above, the ratio

$$R_2O_3 : P_2O_5 : H_2O = ·1756 : ·1706 : ·1639 = 1 : 0·97 : 0·93$$

or the ratio of a normal phosphate, plus one molecule of water $= R_2(PO_4)_2H_2O$.

If the water given off at 100° alone belongs to the carbonate, we have the following ratio for the carbonate:

$$R_2O_3 : CO_2 : H_2O = ·0271 : ·0814 : ·0828 = 1 : 3 : 3·06 = R_2(CO_3)_3\, 3H_2O$$

and for the phosphate:

$$R_2O_3 : P_2O_5 : H_2O = ·1756 : ·1706 : ·3267$$
$$= 1 : 0·97 : 1·86 = R_2(PO_4)_2\, 2H_2O \text{ nearly.}$$

The former seems the more natural supposition and accounts for a carbonate which is known to exist. The mineral as analyzed may then be considered a mixture of lanthanite with the new phosphate in the following proportion:

Lanthanite $R_2(CO_3)_3 9H_2O$.	
CO_3	3·59
$(La, Di)_2O_3$	9·03
H_2O	4·42
	17·04%

Scovillite $R_2(PO_4)_2H_2O$	
P_2O_5	24·84
$(Y, Er)_2O_3$	8·51
$(La, Di)_2O_3$	46·14
Fe_2O_3	·25
H_2O	2·95
Scovillite	82·79%
Lanthanite	17·04%
	99·83

Below we have given the 82·79 per cent of scovillite calculated up to 100 per cent, and beside it that of a normal phosphate of the formula $R_2(PO_4)_2H_2O$ calculated from the atomic weights obtained from the analyses and with $(Y, Er)_2O_3 : (La, Di)_2O_3 = 1 : 4$.

	Scovillite found.	Calculated.
P_2O_5	30·12	29·46
$(Y, Er)_2O_3$	10·28	11·51
$(La, Di)_2O_3$	55·73	55·29
Fe_2O_3	·30	----
H_2O	3·57	3·74
	100·00	100·00

The only mineral which approaches this composition is churchite,* a phosphate of cerium, didymium and lime with four molecules of water. Our mineral contains less water, is free from cerium and lime, and differs also entirely from churchite in physical characters. It is, therefore, a new mineral species, and we propose for it the name *Scovillite*, after the locality where it was found. As to the admixture of the carbonate with the phosphate, we have been unable to decide whether this was due to a simultaneous deposit of lathanite with scovillite, or whether the lanthanite is subsequent in formation to the scovillite and a product of its alteration. At all events the carbonate is very intimately and constantly mixed with the phosphate, as we have found no single fragment which would not give off carbonic acid when dissolved in acid. The carbonate, if resulting from the alteration of the scovillite, is not present as a superficial coating because the fragments when dissolved in acids continue to give off carbonic acid until they are completely dissolved. We take pleasure in acknowledging our indebtedness to Mr. Adam for calling our attention to the peculiar character of this mineral, as well as for his kindness in supplying us with the material for examination.

Sheffield Scientific School, May 8, 1883.

* Chemical News (1865), xii, 121 and 183.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *A Numerical Estimate of the Rigidity of the Earth;* by G. H. Darwin, F.R.S. (Proceedings of the British Association for 1882.)—About fifteen years ago Sir William Thomson pointed out that, however it be constituted, the body of the earth must of necessity yield to the tidal forces due to the attraction of the sun and moon, and he discussed the rigidity of the earth on the hypothesis that it is an elastic body.

If the solid earth were to yield as much as a perfect fluid to these forces, the tides in an ocean on its surface would necessarily be evanescent, and if the yielding be of smaller amount, but still sensible, there must be a sensible reduction in the height of the oceanic tides.

Sir William Thomson appealed to the universal existence of oceanic tides of considerable height as a proof that the earth, as a whole, possesses a high degree of rigidity, and maintained that the previously received geological hypothesis of a fluid interior was untenable. At the same time he suggested that careful observation would afford a means of arriving at a numerical estimate of the average modulus of rigidity of the earth's mass as a whole. The semidiurnal and diurnal tides present phenomena of such complexity, that it is quite beyond the power of mathematics to calculate what these heights would be, if the earth's mass were absolutely unyielding. But the tides of long period are nearly free from the dynamical influences which render those of short period so intractable to calculation, and must in fact nearly follow the laws of the "equilibrium theory."

In 1867 it was not, however, even definitely known whether or not the tides of long period were of sensible height at any station. Although there has been a continual advance in the knowledge of tidal phenomena since that time, it is only within the last year that there is a sufficient accumulation of tidal observations, properly reduced by harmonic analysis, to make it possible to carry out Sir William Thomson's suggestion. The great advances in knowledge that have been recently made are principally due to the adoption of systematic tidal observation at a great number of stations by the Indian Government. The results of these observations are now being issued yearly by the Secretary of State for India in the form of tide-tables for the principal Indian ports. I have had the pleasure of carrying out the examination of the tidal records, and a detailed account of the work will appear at § 848 of the new edition of Thomson and Tait's "Natural Philosophy," now in the press.

The tides chosen for discussion were a lunar fortnightly declinational tide, and the lunar monthly elliptic tide. These tides must be free from the meteorological disturbances which make the heights of all the solar tides quite beyond prediction. The

fortnightly and monthly tides consist in an alternate increase and diminution of the ellipticity of the elliptic spheroid of which the sea level (after elimination of the tidal oscillations of short period) forms a part. There are two parallels of latitude, respectively north and south of the equator, which are nodal lines, along which the water neither rises nor falls. When, in the northern hemisphere, the water is highest to the north of the nodal line of evanescent tide, it is lowest to the south of it, and *vice versa;* and the like is true of the southern hemisphere. If the ocean covered the whole earth the nodal lines would be in latitudes 35° 16′ N. and S. (at which latitudes $\frac{1}{3} - \sin^2 lat.$ vanishes); but when the existence of land is taken into consideration, the nodal latitudes are shifted. Now according to Sir William Thomson's amended equilibrium theory of the tides, the shifting of the nodal latitudes depends on a certain definite integral, whose limits are determined by the distribution of land on the earth's surface.

For the purpose of examining the tidal records, it was therefore first necessary to evaluate this integral. Approximation is of course unavoidable, and for that end the irregular contours of the continents were replaced by meridians and parallels of latitude, and the integrals evaluated by quadrature. This procedure will give results quite accurate enough for practical purposes. It appeared as the result of the quadrature that, if we assume the existence of a large antarctic continent, the latitude of evanescent tide is 34° 40′, and if there is no such continent it is 34° 57′. Hence the displacement of the nodal latitudes due to the existence of land is very small.

This point having been settled, the mathematical expressions for the fortnightly and monthly tides are completely determinate, according to the equilibrium theory, with no yielding of the earth's mass.

If there is yielding of the earth, either with perfect or imperfect elasticity, and with frictional resistance to the motion of the water, the height of tide and the time of high-water must depart from the laws assigned by the equilibrium theory. This conclusion may also be stated in another way, which is more convenient for practical purposes; for we may say that at any station there must actually be a tide with a height equal to some fraction of the full equilibrium height and with high-water exactly at the theoretical time, and a second tide, of exactly the same nature, with a height equal to some other fraction of the equilibrium height, but differing in the time of high-water by a quarter-period from the theoretical time, viz: about three-and-a-half days for the fortnightly and a week for the monthly tide. These two tides may, according to geometrical analogy, be called perpendicular component tides. According to the theory of the composition of harmonic motions, the two components may be compounded into a single tide, with time of high-water occurring within a half-period of the theoretical time; and this is the way

in which the results of elastic yielding and frictional resistance were first stated above. Thus the actual tide at any station involves two unknown fractions, x and y, being the factors by which two components, each of the full theoretical height, are to be multiplied in order to give the two components in proper amount to represent the reality.

If the equilibrium theory is fulfilled without sensible elastic yielding of the earth, the first component has its full value, or x is equal to one, and the second component vanishes, or y is zero. If fluid friction exercises a sensible influence, y will have a sensible value; and if the solid earth yields tidally, x will be less than unity. The amount of elastic yielding, and hence the average modulus of elasticity of the whole earth may be computed from the value of x. After rejecting the observations made at certain stations for sufficient reasons, I obtained from the Tidal Reports of the British Association and from the Indian Tide Tables, the results of thirty-three years of observation, made at fourteen different ports in England, France and India.

These results, when properly reduced, gave thirty-three equations for the x and thirty-three for the y of the fortnightly tide, and similarly thirty-three for the x and thirty-three for the y of the monthly tide; in all 132 equations for four unknowns.

The x and y of the two classes of tide were in the first instance regarded as distinct, but the manner in which they arise shows that it is legitimate to regard them as identical, and thus we have sixty-six equations for x and sixty-six for y.

The equations were then reduced by the method of least squares, with the following results:—

For the fortnightly tide—

$$x = \cdot 675 \pm \cdot 056, y = \cdot 020 \pm \cdot 055$$

And for the monthly tide—

$$x = \cdot 680 \pm \cdot 258, y = \cdot 090 \pm \cdot 218$$

The numbers given with alternative signs are the probable errors.

The very close agreement between the x and y for the two tides is probably somewhat due to chance.

The smallness of the two y's is satisfactory; for, as above stated, if the equilibrium theory were true, they should vanish. Moreover, the signs are in agreement with what they should be, if friction is a sensible cause of tidal retardation. But considering the magnitude of the probable errors, it is of course more likely that the non-evanescence of the y's is due to errors of observation or to the method of reduction.

I have already submitted to the British Association at this meeting a paper on a misprint, discovered by Professor Adams, in the tidal report for 1872. This report forms the basis of the method of harmonic analysis which has been employed in the reduction of the tidal observations, and it appears that the erroneous formula has been systematically used. The large probable

error in the value of the monthly tide may most probably be reduced by a correct treatment of the original tidal records.

It has been already remarked that it is legitimate to combine all the observations together, for both sorts of tide, and thus to obtain a single x and y from sixty-six years of observation. Carrying out this idea I find:

$$x = \cdot 676 \pm \cdot 076,\ y = \cdot 029 \pm \cdot 065$$

These results really seem to present evidence of a tidal yielding of the earth's mass, and the value of the x is such as to show that the effective rigidity of the whole earth is about equal to that of steel.

But this result is open to some doubt for the following reason:

Taking only the Indian results (forty-eight years in all), which are much more consistent than the English ones, I find

$$x = \cdot 931 \pm \cdot 056,\ y = \cdot 155 \pm \cdot 068$$

We thus see that the more consistent observations seem to bring out the tides more nearly to their theoretical equilibrium values with no elastic yielding of the solid.

It is to be observed, however, that the Indian results being confined within a narrow range of latitude give (especially when we consider the absence of minute accuracy in my evaluation of the definite integral) a less searching test for the elastic yielding than a combination of results from all latitudes.

On the whole we may fairly conclude that, while there is some evidence of a tidal yielding of the earth's mass, that yielding is certainly small, and that the effective rigidity is at least as great as that of steel.

2. *On Ripple-marks.*—Two memoirs on the formation of ripple-marks have recently appeared; one, by Mr. A. R. Hunt, in the Transactions of the Royal Society for 1882, and the other by Mr. C. DeCandolle, in the Geneva Archives des Sciences for March 15, 1883. The latter is the more thorough in its treatment of the subject, and gives experimental illustrations. The author announces early in his paper the following general law as the result of his study.

When any viscous matter in contact with a liquid of less viscosity undergoes oscillatory or intermittent friction resulting from movement in the overlying layer, or from its own displacement relatively to this layer, (1) the surface of the viscous matter becomes rippled perpendicularly to the direction of the oscillation, and (2) the distance between the ripples so formed is in direct ratio to the amplitude of the oscillation.

The expression *viscous matter* here includes not only liquids that are evidently viscous, as syrups, tar, etc., but also mixtures of insoluble powders with non-viscous liquids, mixtures which are never as perfectly fluid as these liquids themselves. Even collections of bubbles of air on the surface of water produce in the mass a feeble degree of viscosity, sufficient to give origin to ripples, as the author has proved by his experiments. If the

two liquids of unlike degree of viscosity are not at all miscible, like mercury and water, or oil of turpentine and water, ripples are not made; but if powdered quartz or barite covers the mercury a mixture of some viscosity is produced by the friction and ripples will form.

Ripples are then the result of oscillatory or intermittent friction. A wave, whether stationary or propagating itself, involves, at the same instant, (1) a change of surface level, and (2) a horizontal oscillation of the liquid molecules; whence the surface against which the wave acts experiences simultaneously a normal impact and oscillatory friction; and this friction is especially pronounced when the motion of the liquid consists in a simple uninodal undulation. No general movement of the mass is necessary.

Thus, the problem of the formation of rippled surfaces is that of the formation of friction waves. In the memoir, the statement of the author's general conclusion is followed by an account of his various experiments, in illustration of which there are four photographic plates representing the rippled surfaces obtained. The first experiments were made in open glass troughs of water to which an undulating motion could be given by moving the trough, or the water directly; the ripples were "*ripples of undulation.*" Each ripple terminated above in a crest consisting of the lighter particles if these were of unequal sizes; and the distance between the ripples was always the same if the amplitude of oscillation and depth were the same. Other experiments were made to ascertain the effects of a rotatory movement in the liquid. The ripples thus produced the author calls *ripples of rotation.* They are radiating ripples, and their distance apart depends, as before, on the amplitude of the oscillatory friction.

With regard to *ripple-marks made in connection with the flow of waters,* like those over sand-flats, the author's experimental trials were not successful. The author says that they are *the result of friction rendered intermittent by continual variations in the velocity of the flow.* He explains in the same way the ripple-marks made over surfaces of dry sand by the winds. The above statement as to their origin does not appear to be quite adequate; for the needed undulations, or intermittent action in flowing waters is chiefly a *consequence of the friction* over the mobile sands, while in the first case the undulation is of independent source. The movement makes the "viscous" mixture as before, but the resistance intermittently overcome produces the undulation in the water and the intermittent deposition. The wave-movement in waters not sensibly flowing produces *ripples of undulation;* and these should graduate imperceptibly into *ripples of translation* as the waters change to shallower flowing waters. Both kinds, however, come under the general law deduced by the author, above cited. As to the depth at which ripples may form, the author quotes an article by the brothers E. F. and W. Weber, published at Leipzig in 1825, in which it is stated, as

the result of experiment, that the oscillation of waves may be appreciable at a depth equal to 350 times the height of the waves.

Mr. DeCandolle suggests that the ripple-like arrangement of clouds may come into the same category with the wind-ripples over dry sands, and that if so, the parallel lines of clouds should be at right angles to the direction of the wind. J. D. D.

3. *Direct vision Spectroscope of great dispersion.*—The dispersion of direct vision spectroscopes does not in general exceed 20° from the A line to the H line. M. Ch. V. Zenger joins to a parallelopipedon of dispersion a prism of light crown glass and obtains a dispersion of 150°, which he claims is only exceeded by the spectroscope of M. Thollon, in which the number of prisms of bisulphide of carbon and multiple reflexions diminish the intensity of the light to a great degree. The combination of M. Zenger is subject in a less degree than M. Thollon's to these reflexions and the loss by absorption is claimed to be small. As an example of the proposed arrangement M. Zenger gives the calculation for a combination of three prisms. One of the prisms was made of quartz (extraordinary refraction), another—a liquid prism—was filled with a mixture of 4 parts of ether to 6 parts of benzine. These two prisms were combined so as to form a parallelopipedon. The limiting angle of the liquid prism for the line A was found to be 76° 11′. A crown glass prism was then placed so as to refract the beam of light which passed through the parallelopipedon. The refracting angle of this crown glass prism was made 27° 13′. With this arrangement a total dispersion of 132° 55′ was obtained. The total dispersion was equivalent to that of thirteen or fourteen bisulphide of carbon prisms of 60°.—*Comptes Rendus*, April 9, 1883, pp. 1039–1041. J. T.

4. *The transmission of power by electricity.*—An interesting report upon this subject has lately been presented to the French Academy by M. Cornu in behalf of a commission which was appointed to examine the experiments of M. Depretz. A careful analysis of the results of the various experiments is given with the following summary:

The work absorbed by the generatrix and transmitted to the receptrix, increases with the velocity of the generatrix. M. Depretz has succeeded in transmitting nearly four and one-half horse power through a resistance of 160 ohms which represents a double telegraph line of $8{\cdot}5^{km}$. The work received was $37\frac{1}{2}$ per cent of that spent.

With a greater velocity of the generatrix it seems possible to transmit power to greater distances than M. Depretz has attained. This amounts to saying that a high electromotive force is necessary for this end.—*Comptes Rendus*, April 9, 1883, pp. 992–1010. J. T.

5. *The radiation of rock-salt at different temperatures.*—C. Baur by means of a bolometer has studied this question, which the researches of Melloni and Magnus have left undecided. The conclusions reached are as follows:—

Rocksalt absorbs its own rays more strongly than those of other bodies.

The absorption increases as the difference in temperature between the radiating and absorbing rocksalt plates diminishes.

The absorption reaches its full value when the difference in temperature between two such plates is nothing. Baur does not believe with Magnus that the radiations from rocksalt are homogeneous; but concludes that long waves are accompanied more or less with longer and shorter waves, just as a yellow glowing solid body sends forth not only yellow but also radiations of a greater wave length.—*Annalen der Physik und Chemie*, No. 5, 1883, pp. 17–21. J. T.

6. *Application of Organic acids to the Examination of Minerals*, No. 3; by H. CARRINGTON BOLTON, Ph.D.—Professor Bolton has continued his investigations as to the action of organic acids on minerals, and obtained some additional results of interest. The acid employed was citric acid, which, as the author has shown, has a power of decomposing minerals little less than that of hydrochloric acid; the effect of prolonged action at ordinary temperatures was especially considered. Of the sulphides, chalcocite showed signs of decomposition at the end of ten days, and after several months a partial solution of a green color was obtained; pyrite was slightly attacked in eight days, and a month later a solution of a reddish-yellow color was obtained; chalcopyrite acted similarly, one gram lost 11 per cent after fourteen months' contact with the acid solution. Of the oxides, magnetite and limonite were experimented upon and found to be strongly attacked in eight days, hematite yielded more slowly, showing decided decomposition after several months. Of the silicates, datolite was most quickly decomposed, yielding gelatinous silica after twenty-four hours; hornblende, pyroxene, almandite, epidote, vesuvianite and serpentine were decidedly decomposed in eight days, and after fourteen months the first two were completely decomposed, the serpentine after the same time yielded a dry gelatinous mass. The feldspars were unequally attacked under like conditions, labradorite yielded most easily, orthoclase and oligoclase showed marked signs of decomposition after eight months, while albite is still doubtful. Tourmaline and staurolite yielded after four or five months, while talc and cyanite seemed to resist attacks. Muscovite and biotite yielded very slowly, the latter showing signs of decomposition the sooner. The author gives a table which shows the approximate relative disintegration of rock-forming (and associated) minerals by citric acid in solution. Those *quickly decomposed* are the carbonates, phosphates, prochlorite, chrysolite and nephelite; those *slowly decomposed* are serpentine, pyroxene, hornblende, labradorite, garnet, epidote, vesuvianite, pyrite, limonite, magnetite, gypsum (?); those *very slowly decomposed* are orthoclase, oligoclase, albite (?), biotite, muscovite, tourmaline, staurolite, hematite; *not decomposed* are quartz, corundum, spinel, beryl, fluorite, barite, talc (?), cyanite (?). The author suggests

that the above facts may have an important bearing upon some evident geological phenomena, but does not discuss the matter further. A series of concluding tables shows in detail the behavior of a large number of minerals with citric acid alone and with reagents.

II. Geology and Mineralogy.

1. *On Pot-holes on the edge of a bluff at Gurleyville, Connecticut;* by Professor B. F. Koons. (Communicated.)—Last November I discovered an interesting group of pot-holes upon the edge of a bluff at Gurleyville, Conn., on the east side of the Fenton River, four miles above its mouth.

Recently, in company with Professor Washburn, I have cleared the one perfect one of its water and stones, and found it to be six feet seven inches in depth, three feet nine inches in its shorter diameter at the top, and four feet three inches in its longer diameter.

About two feet above the bottom the diameter is reduced to about thirty inches, and then widens again below this point, leaving a horizontal ring at the narrow place. What can have been the cause of the forming of the ring at this point is not entirely evident. If the rock were horizontal it would seem that a hard layer in the rather uniform gneiss would account for it; but since the rock dips at an angle of about 30°, and this projecting ring is horizontal and only a couple of inches thick, I find myself at a loss for an entirely satisfactory answer.

This pot-hole is near the edge of the cliff and the remnants of three others appear upon the face of it; and one of these three shows a diameter of nine feet and a depth of six. All are within a few feet of each other, a couple of them separated by a thin partition only. They are upon the projecting point of a cliff at the foot of a narrow passage through which the glacial stream made its way, and just where an eddy would be formed by the rushing waters as they spread out into the wider plain below. The group is all the more interesting from the fact that the pot-hole highest on the cliff stands ninety-eight feet six inches above modern flood plain, while the highest terraces to be found in the vicinity are only fifty-six feet six inches high.

Storrs Agricultural School, Mansfield, Conn., April 21st, 1883.

2. *The Geology of Pike and Monroe Counties, Pennsylvania,* by I. C. White; *and Special Surveys of the Delaware and Lehigh Water Gaps,* by H. M. Chance.—The publication of this volume of the Geological Survey of Pennsylvania is announced on page 310 of this volume. Pike and Monroe Counties are on the eastern border of the State, with only the county of Wayne between Pike and the northern boundary. Mr. White's volume treats of many points of great interest, with a full supply of facts from his careful observations.

The front or eastern edge of the great plateau of the two

counties—1200 to 2000 feet above the sea-level—is made by an irregularly continuous mountain wall, a thousand feet high and precipitous, broken only by short ravines, the southern part of which is called Pocono Mountain. The rocks of the plateau are nearly horizontal, as in the corresponding plateau of the Catskill Mountain region to the northeast. A map accompanying the Report, by Professor Lesley, represents the Catskill Mountain escarpment as continued, though with diminished height, in the escarpment through Pike County, and then with increase of elevation again, through Monroe County along Pocono Plateau and Mountain, about 2000 feet in elevation, from which the surface southward falls off precipitously 1200 to 1300 feet. Pike County, over its higher parts, is covered with rocks of the Catskill group. The Kittatinny Mountain, consisting of Devonian and Silurian strata, down to the Hudson River slates, extends along the eastern border of the counties on the New Jersey boundary.

The *glacial scratches* over the counties have in general a course of S. 30° W., except where locally diverted. This course is that also over the Kittatinny or Blue Mountain. The abrading action of the glaciers over the region was small, and "exerted practically no influence in modifying the general topography;" but much tearing or disrupting was done over the jointed rocks.

The district is "remarkable for the number and variety of its *buried valleys*." "Between Port Jervis and the Water Gap, the Delaware River flows over an old river channel silted up to a depth of perhaps 100 feet." Other buried valleys are the Stroudsburg and Flat Brook. In the case of the southern branch of the Stroudsburg, "the rapid narrowing up and disappearance of this *buried valley* is coincident with the disappearance of the Terminal Moraine which spreads over the valley of Upper Frantz's Creek. There is therefore little doubt that *subglacial rivers* did both widen and deepen it to a considerable extent, for Frantz's Creek, after entering the *driftless* region, flows along its narrow valley in the same soft Marcellus shale which underlies its wide drift-filled eastern prolongation." The author observes that the facts show that the direct abrading action of the glacier over the soft rocks must have aided in the excavation. Among buried valleys there are "also post-glacial rock-cuts" as in the new channel of Wallenpaupack Creek, of Blooming Grove Creek, Shohola Creek, Sawkill River, and others.

The larger part of Mr. White's Report is occupied with the stratigraphy of the counties and of part of the adjoining Carbon County to Mauch Chunk. In the course of the descriptions it is stated that while the thickness of the Catskill series was found by the author, as before reported, to be 1530 feet on the northern boundary of Wayne County; in Pike County, near Wayne, it is 3430 feet; along the Lehigh, below Mauch Chunk, 7544 feet.

The unconformability of the Oneida Conglomerate or lowest member of the Upper Silurian over the Hudson River shale or top of the Lower Silurian, is spoken of "as finely shown at a cut

on the Erie railroad, a mile west from Otisville, in New York," the dip of the former being 28°, and of the latter 43°, the direction in each case north-northwest; and, besides, the latter rock has an eroded surface and chips of it occur in the conglomerate. Similar evidences of unconformability were observed at the Lehigh Water Gap.

From the prefatory letter, introductory to the Report, by Professor Lesley, Director of the Geological Survey, we cite the following:

"The body of the Catskill plateau consists of the Catskill formation (uppermost Devonian, No. IX of the former survey), about 5000 feet thick, and the peaks are what remains of the overlying gray Subcarboniferous, the Pocono formation (No. X), which formerly spread continuously over the Catskill beds. Mr. White has illustrated this point by facts from Wayne, Pike and Monroe Counties. Above the latter the Mauch Chunk Red shale formation (No. XI), the Pottsville Conglomerate (No. XII), and the Coal Measures (No. XIII), once lay; whence Mr. Lesley concludes the original height of the Catskill Mountain mass must have been at least 11,000 feet, if not 12,000 feet.

The Catskill table-land is at least 125 miles long, half in New York, half in Pennsylvania. From Pocono Mountain it extends westward into Carbon County as the Nesquehoning Mountain, and northward as Moosic Mountain, and again westward, by the Elk Mountains, across the Susquehannah River, becoming the North or Allegheny Mountain uplands. He observes that it must be regarded as one broad synclinal rising toward the northeast, through which run lengthwise (N.E. and S.W.) gentle anticlinal undulations, that west of the Delaware become steep anticlines.

The fact of the increase in thickness and coarseness of the Paleozoic fragmental beds from New York to Alabama points to, if it does not prove, says Professor Lesley, "the derivation of the sediments from the Archæan highlands of New England, Southern New York, Northern New Jersey, the South Mountains of Pennsylvania, the Blue Ridge range of Virginia and the Black Mountains of North Carolina; or, in place of some of these, which were early covered with Paleozoic sediments, to Archæan Alps still farther off, now buried beneath the shore deposits or beneath the waters of the Atlantic."

Professor Lesley mentions the course of the "terminal moraine" as ascertained by Mr. Lewis, who has this subject in charge, but adds that the existence of ice-striæ on the crest of Locust Mountain, west of Ashland and 25 miles south-southwest of the nearest part of the great moraine, suffices to show that much is yet uncomprehended.

The Report contains a large colored geological map, by Mr. White, and sections and maps by Mr. Chance.

3. *Geology of Philadelphia County and of the other parts of Montgomery and Bucks Counties*, by CHARLES E. HALL, with

analyses of rocks by Dr. F. A. Genth and F. A. Genth, Jr. 144 pp. 8vo, with maps.—Mr. Hall's volume is one of the most important that has come from the Second Geological Survey of Pennsylvania. The author describes and represents in sections the conformability of the crystalline limestones, hydromica schist and other crystalline schists, and quartzytes, proving that all are of one series and none of them older than Lower Silurian. The facts prove that the rocks are a continuation of the Taconic and other formations of the Green Mountain region, being similar both in lithological characters and stratigraphical relations.

4. *On the Relations of the Triassic traps and sandstones of the Eastern United States;* by WM. M. DAVIS. Bulletin of the Mus. Comp. Zool., vol. vii (Geol. series, vol. i), 8vo, pp. 249–309, with numerous sections.—This paper is the full memoir on the Triassic sandstones and trap of Eastern North America which the author promised in his abstract of his views given in the last volume of this Journal (p. 345).

The uniformity in features of the long trap ridges in the Triassic areas of Eastern North America, the trap in all those of a nearly north and south course having a bold columnar front in one direction and a gradual slope in the opposite, and their occurrence in long lines, sometimes in many nearly parallel, as well shown on Percival's map, have led most observers, as they did Percival, to regard all as intrusive, but with lateral outflow to some distance between layers of sandstone. The object of Professor Davis's memoir is to show, as the result of his investigations, that, notwithstanding this uniformity, part of the trap ridges are intrusive, and part *overflows* covered by beds of the sandstone of later origin, which tilting and faulting have put into their present positions. He makes the Palisades, on the Hudson, East Rock and West Rock ridges, near New Haven, and some others, to be certainly intrusive, but many others, undistinguishable from these in general features, to be overflows. The occurrence of any amygdaloid in the trap is regarded by him, for reasons which he gives, as one evidence of an overflow.

The author's sections make his views clear to the reader. In his text he is strong in many of his statements as to the conclusions from his investigations, but says that in Connecticut much observation is still necessary to decide finally on the origin of the numerous ridges. The writer has made many observations in Connecticut bearing on the question at issue, and has not yet detected any satisfactory evidence of the overflows. A discussion of the subject is deferred until further observations can be made, when the facts, for or against, will be presented.

As to the origin of the vesicular texture of the amygdaloid the writer has always held, in agreement with the author, that the feature was due to "a decrease of pressure which allowed the occluded gases and vapors to separate from the surface of the overflowing mass;" that is, if this means a decrease of pressure which allowed the moisture or other material in the melted rock

to become vapor toward its surface or in its outer portion. But the indications of moisture in the trap of the ridges are not in the amygdaloidal cavities alone, or chiefly, but vastly more in the general hydration of the trap, rendering it chloritic at the expense of the pyroxene or pyroxene and feldspar. Often a very small part only, if any, of a hydrous trap ridge is amygdaloidal; the hydrous condition appears to belong to the mass. And this is parallel with common facts in other regions, such hydrous trap (sometimes called melaphyre), being frequently the only kind. The feature is independent of pressure, and is a prerequisite to the amygdaloidal. The distinction to which the observations of E. S. Dana seemed to lead was that the masses of the several trap ridges in Southern Connecticut became gradually more and more chloritic, or hydrous, on going from west to east over the Triassic area; and that the amygdaloidal feature was a subordinate one, occasionally observed where the hydration was greatest. J. D. D.

5. *Glacial phenomena of Long Island*, by JOHN BRYSEN, Esq. (Geological Magazine, April, 1883, x, p. 169.)—This paper, on Long Island Glacial phenomena, is by one who says of himself that he is "by no means a scientist." We believe this statement, and see little else in the paper to accept with so much confidence. The author informs his readers much that nobody else knows. He says that in the Glacial era "the Sound [Long Island Sound] or [and] East River did not yet exist"; the "waters flowed *around* not through Hurlgate"; "the waters of the Hudson, Connecticut, and other rivers flowed directly into the sea"; the waters of the streams "underneath the glacier," "wild and turbid streams," dammed up by the terminal moraine, broke through the main ridge or back bone of the island; and their depth was so great that the water-worn stones were carried by the current—"not by the drift" to the top of Harbor Hill, the highest point of the island. [The greatest height according to the Coast Survey is 383 feet.] This incredible fact is thought not to seem impossible "when we remember that the glacier was from ten to fifteen thousand feet in thickness," and that "it was *under* the glacier that these mighty torrents prevailed."

6. *Relations of the "Felsyte" to the Conglomerate on Central Avenue, Milton, Mass.*, to the south of Boston.—Professor M. E. WADSWORTH has given the results of his observations on the Milton "felsyte" in the Harvard University Bulletin of October, 1882. They differ widely from those of Professor W. O. Crosby in vol. xix of this Journal (1880). He states that the felsyte is only a somewhat altered portion of the associated conglomerate. It contains in some parts many argillaceous pebbles only partly obliterated, and the two rocks graduate into one another. The conclusion was sustained also by microscopic examinations. Proof of distinct bedding east and west in strike was found to be indicated by lines of finer and coarser sedimentation. A few rods south of the "felsyte" locality, a coarse conglomerate alternates

repeatedly with bands of sandstone, in which occur pebbles of argillyte which vary from a minute size up to a length of one to two feet. The argillyte resembles that "exposed to view on the O. C. Mattapan branch railroad, a short distance to the northwest;" whence the inference that the conglomerate is younger than the argillyte; and Mr. Wadsworth also observes that the conglomerate is of different age from the Roxbury conglomerate of the same part of the Boston basin.

7. *Jointed structure in rocks.* — In a paper on the origin of jointed structures, in the Proceedings of the Boston Society of Natural History for October, 1882, p. 72, Professor W. O. Crosby explains the joints ordinarily so-called, having great uniformity in direction, to the vibrations of earthquakes, stating that the character of the vibrations is such as necessarily to produce fractures, and that all formations have been subjected to severe shocks of indefinite number.

8. *Note on Jointed structure.*—It would appear from Mr. W. J. McGee's note (this Journal, February, 1883, p. 153), that his observations on jointing are strongly in favor of their being due to the contraction of rock masses. As has been mentioned in "Valleys and their relations to Faults, etc." (Trübner & Co., London), chaps. i and ii, very similar phenomena have been observed in Irish limestone and other rocks. Master-joints of different ages, the *clay seams* and *dry seams* of McGee, or the *red end and end* of the Irish quarrymen, usually have different bearings, the younger crossing the older at any angle up to right angles. The older necessarily have opened toward the surface more than the younger, and the shrinkage spaces have become filled with clay; but in depth they have not opened, being still mere lines, that is, a clay seam passing into a dry seam. In the face of the "head" or "clearing" over the marble beds at Galway, Ireland, which in 1865 was over 150 feet high, this was well illustrated. When these quarries ceased working, about 1850, there were no joints in the beds forming the floor of the quarry except "concealed joints," that showed and opened as the blocks were wedged up, but after the floor had laid exposed to the weather about fifteen years, shrinkage had changed all these concealed joints into open joints. G. H. KINAHAN.

9. *Origin of the Crystalline Iron Ores.*—Dr. A. A. Julien read a paper on this subject before the New York Academy of Sciences, in October last (Trans. N. Y. Acad. Sci., ii, p. 6). The author presented the view that the large iron ore deposits of the Archæan were originally made mechanically, like the accumulations of iron-sand along sea beaches; or, in some cases, as he stated at the following meeting, "accumulations upon a sea-bottom strewn alternately with fine siliceous silt and with octahedra of magnetite." Dr. Newberry discussed the subject in reply, admitting that some beds may have been made by "the sorting power of shore waves," but urging that such cases are exceptional, and arguing in favor of the more common theory that they

are derived from the precipitation of iron oxide from its soluble salts in waters receiving the drainage of a region, the waters being, in his view, those of a confined area or lake. Some of the facts regarded by Dr. Newberry as unfavorable to the idea of a mechanical origin, are the thickness of many of the Archæan ore-deposits; their being enclosed sometimes by strata of limestone or of slate, rocks made by *quiet* methods of deposition, unlike those of iron-sand; the occurrence of alternating beds of jasper, another rock of fine and quiet sedimentation; and the existence of beds of aluminous magnetites, which contain almost no silica. Dr. Julien states rightly that some magnetite is associated with much garnet. When this is the case the probability is in favor of the mode of origin he presents—a method hitherto too much overlooked. But Dr. Newberry's position appears to be the right one—that this method is not the usual one, and makes only thin seams of ore.

The beach deposits of iron-sand are made by the fling or forcible transporting action of waves, followed by the action of the returning waters in drifting away from the heavier sands the most of the lighter grains as those of quartz. It is thus that the magnetite and garnet are concentrated on the highest parts of the sand-made beaches, as implied by Dr. Newberry; and hence ore-deposits of this mode of origin are necessarily of small extent, and vary at short intervals in the proportion of siliceous sands. The conditions are such as would not make *sea-bottom* deposits of the ore; and it is questionable whether in deposits so formed the iron-sands are not always distributed throughout the sediments, as is so commonly the case in sandstones.

The successive phases of a coal era—where open seas have alternated with immense salt-water mud-flats or marshes, becoming afterward fresh-water mud-flats, and the reverse, with the transitions between these different states, include the conditions as to confined areas fitted for chemical iron-ore deposits. Such are the conditions which the writer has had in view when speaking of the ore as originally a marsh-made deposit; and such he understands to be the view of Dr. Newberry. J. D. D.

10. *Overturn folds in the Glaronnaise Alps.*—The idea of a double overturn fold in the Glaronnaise Alps, first presented by Escher, and afterward adopted and illustrated with full details by Heim, led to an excursion over the region in 1882 by a party of sixteen geologists, under the guidance of M. Heim, in order to see and understand the facts in the case. The party included Messieurs Lory, de Grenoble, Rothpletz of Munich and Vilanova of Madrid. The result was the general acceptance of Heim's conclusion as to the enormous overturn. M. Lory was fully convinced as to the double fold. M. Rothpletz admitted the existence of the southern fold, but objected to that of the northern, explaining the position of the formations in the latter region by a fault combined with a sliding of the beds.—*M. E. Favre, Archives des Sc. Phys. et Nat.*, III, ix, 180, Feb., 1883.

11. *The Dimetian, Arvonian and Pebidian formations.* — These subdivisions of the Pre-Cambrian, proopsed by Dr. Hicks from his observations at St. David's, on the ground of mutual unconformability, the Pebidian being the youngest, are the subject of a paper by Professor Archibald Geikie, read before the Geological Society in March. Professor Geikie, after an examination of the region, concludes that the *Pebidian* group, which comprises a series of volcanic tufas, breccias and lavas, is an integral part of the Cambrian; the *Dimetian* is eruptive granite intersecting the Cambrian; and the *Arvonian*, eruptive quartz-porphyries or elvans associated with the granite—proof of which was found in natural sections showing the actual intrusion of the elvans across the bedding of the rocks.

12. *On the results of Recent explorations of erect trees containing Animal remains in the Coal Formation of Nova Scotia;* by J. W. Dawson.—Part II of Dr. Dawson's memoir is published in the Philosophical Transactions for 1882.

13. *Lethæa Geologica;* 1 *Theil. Lethæa Palæozoica*, von Ferd. Roemer. Textband, zweite Lieferung. 327 – 544 pp., with 65 wood-cuts. 8vo. Stuttgart, 1883. (E. Schweizerbart.)—This part of the Lethæa, by Roemer, is devoted wholly to fossil Corals, and will be found of great service to American paleontologists.

14. *Hemidioryte;* J. D. Dana.—In the writer's paper "on some points in Lithology," published in 1878 in volume xvi of this Journal, I present, on page 434, objections to calling a rock made of mica and a triclinic feldspar a mica-dioryte: stating (1) that the name "diorite" was given originally to a hornblendic rock and (2) that black mica (biotite) and hornblende, although both are ferriferous, are in fact widely diverse minerals, mica, unlike hornblende, being essentially a potash-bearing species, and nearly as much so as orthoclase; and adding that it is, therefore, undesirable, both geologically and lithologically, to put rocks having mica as a characteristic ingredient under the same general name with those that are essentially hornblendic. Accordingly, in my articles on the Cortland rocks in this Journal for 1880 on page 198 of volume xx, I called a rock of the kind here referred to simply a *soda-granite*, in allusion to its resembling granite in aspect and in being a compound of feldspar and mica, with more or less quartz, and to its containing a soda-lime feldspar, oligoclase, instead of orthoclase.

As it is best that the rock should have a distinctive name I would propose for it that of *Hemidioryte*, which recognizes its relation to dioryte, without merging it in the dioryte group.

15. *Jeremeieffite, a new mineral.*—M. Damour has recently described a new borate of alumina from Siberia under the name Jeremeieffite, after the Russian mining engineer Mr. Jeremejew. It crystallizes in regular hexagonal prisms, and thus resembles apatite and beryl in habit. Hardness 6·5, specific gravity 3·28. Transparent and almost colorless with vitreous fracture. An analysis yielded:

B_2O_3 by difference.	Al_2O_3	Fe_2O_3	K_2O
[40·19]	55·03	4·08	0·70 = 100

These results correspond closely with the formula $(Al_2O_3,Fe_2O_3)B_2O_3$. Before the blowpipe it loses its transparency and colors the flame green (boron) without fusing, moistened with cobalt solution it yields a fine blue. It is not attacked by acids except when first ignited at a red heat, when heated sulphuric acid dissolves it. The locality from which this interesting mineral was obtained by the engineer whose name it bears is the Soktoui, southeast of Adun-Tschilon in western Siberia.—*Bull. Soc. Min.*, vi, 20, 1883.

16. *Picro-epidote, a new magnesian epidote.*—MM. Damour and DesCloizeaux have described a new member of the epidote group in which magnesia enters in the place of lime. The crystals which have been examined by M. DesCloizeaux, though too imperfect to allow of exact determination, correspond with ordinary epidote in angle and in optical properties. The crystals are small, transparent to translucent, and of a white or slightly yellowish tint. They scratch glass and are infusible in the blowpipe flame. M. Damour has shown as the result of some qualitative tests that the mineral is a silicate of alumina and magnesia with traces of lime, and it is inferred that the composition must be analogous to that of epidote. The specimens examined were associated with lapis lazuli, calcite, dolomite, diopside and pyrite. The locality is Lake Baikal.

17. *A Text-Book of Mineralogy, with an extended treatise on Crystallography and Physical Mineralogy;* by Edward Salisbury Dana. Revised edition. 521 pp. 8vo. New York, 1883. (J. Wiley & Son.)—The new edition of the Text-Book of Mineralogy contains about fifty pages of new matter arranged in four supplementary chapters. These chapters give descriptions of new instruments for the measurement of crystals, and for the study of their optical properties, illustrated by numerous woodcuts; also an account of new methods of determining the specific gravity of minerals, their indices of refraction, and other related points; further, brief descriptions of new minerals, and a statement of important new facts in regard to the characters and occurrence of old species. The larger portion of the book remains as it was in the earlier edition except as regards occasional corrections, references, and so on. The book has been re-paged, and a new and complete index concludes the volume.

III. Botany and Zoology.

1. *Jahrbuch des K. Botanischen Gartens und des Botanischen Museums zu Berlin.* Band II, 1883.—The second volume of this new work has promptly come to hand. Dr. Eichler, the Director of Gardens, and Dr. Garcke, Curator of the Museum, are associated in the editorship: the latter was the editor of the Linnæa, which the present publication supersedes. The leading article

of the volume is a full Monograph of the *Turneraceæ* by Urban. He retains Aublet's *Piriqueta*, and reduces Dr. Chapman's three species to one, *P. Caroliniana*. The medicinally famous *Turnera aphrodisiaca* is made a variety of *T. diffusa* Willd., which has a wide range and a copious synonymy. The same author has a paper on the biology and morphology of *Rutaceæ*. Wenzig contributes a synopsis of the genera and species of *Pomaceæ*, a summary of his revision in the 38th volume of the Linnæa. A leading physiological article is that of Volkens, on the excretion of water in a liquid form by the leaves of the higher plants. In another, Potonie treats of the arrangement of the conductive bundles in the Vascular Cryptogamia. Dr. Paul Schultz has a very interesting paper on the medullary rays and their relations to the conducting elements in wood. He shows that the medullary rays of Coniferæ are connected with wood-cells by means of pores. These pores in the ray-cells are always unbordered, but in the wood-cells may have the characteristic border of the discoid markings. In a few species of Pinus, with large pores to the ray-cells, the neighboring wood-cells are strengthened at the point of contact by means of delicate cross-beams or braces. True wood-cells were met with in the medullary rays only of the *Abietenæ*, and under two modifications; in the first, the cells are irregularly thickened, in the other they are very narrow and not irregularly lignified. The ray-cells with pores serve as receptacles for water. In Dicotyledons, the ray-cells are united to the vessels by means of pores which sometimes attain a surprising size. Finally, Schulz concludes that woody parenchyma and ray-cells stand in intimate relations to vessels, and that they together form the channels for transfer of organic solutions. This conclusion is based upon experiments made on branches of Horse-Chestnut, in spring. As it is impossible to follow the course of a solution of sugar after it has been made to enter the plant, he used a dilute solution of tannin which was introduced by absorption from a tube in a small aperture going down to the wood. The tannin was afterwards tested for by iron solution. G. L. G.

Dr. SCHRÖTER contributes a short article on the *morphology of the andrœcium of Malvaceæ*, from a study of *Sida* and *Hibiscus*. He confirms the conclusion that the andrœcium arises from five epipetalous stamineal leaves, developed earlier than the petals themselves, and multiplying both by collateral and transverse chorisis; but he finds no evidence in *Hibiscus* of an inner and episepalous series of stamens. The decisive plant to study in this regard is *Sidalcea diploschypha*. And we beg seeds of this from our Californian correspondents, that we may place them in the hands of the proper investigators. A. G.

2. *Flora of the Southern United States.*—The crying want has at length been supplied. Dr. Chapman has brought out a second edition of his Flora of the Southern States east of the Mississippi. The preface to the new issue has the date of December 26, 1882. The Supplement was printed and some copies distributed at the

close of winter. But the volume, a reissue of the original edition, with some typographical corrections, with appended supplement, comes to hand only in May, rather late for this year's use in the southern Colleges, and by the botanical amateurs who winter in Florida. The supplement of 70 pages contains the species which have been discovered within the limits of the work during the intervening twenty-two years. These are about 440 in number; the majority being of a tropical or subtropical cast and from the peninsula of Florida; some are naturalized foreigners, a considerable number from the mountains, a fair number first made known to science by Dr. Chapman himself. The veteran author announces his intention of preparing a final edition in place of this reprint, bringing the Southern Flora up to date. We heartily wish him health and strength to carry this laudable determination into effect, and that he may live to enjoy the fruit of his labors. A. G.

3. *Genera Plantarum.*—Auctoribus G. BENTHAM et J. D. HOOKER. Vol. III, part 2, pp. 447–1248.—This concludes the work, was issued in April last, and copies are now in the hands of American botanists. It should be understood that the work is restricted to Phænogamous Plants, the Cryptogamia being relegated to specialists. That must needs be for the Lower Cryptogamia, and under the circumstances for the higher orders as well,—much as it were to be desired that the Ferns should be elaborated, from an experienced general botanist's point of view, by the venerable senior author of the Genera Plantarum which is now happily completed as to the Phanerogamia. We hope to give some further account of this concluding volume. A. G.

4. *Monographiæ Phanerogamarum.* Auct. ALPHONSO et CASIMIR DECANDOLLE. Vol. IV. March, 1883.—Nearly all the volume is the work of Professor Engler of Kiel, consisting of a very careful re-elaboration of the *Burseraceæ* and the *Anacardiaceæ*. Refining a little on the genera as admitted by DeCandolle and by Bentham and Hooker, Engler restores not only *Lithræa* of Miers, but also *Cotinus* and *Metopium* of old authors. Fifteen plates are well filled with analyses of the genera of these orders. The Monocotyledonous orders are not much advanced in this volume, containing, as it does, only a monograph of the *Pontederiaceæ*, by Solms-Laubach, the descriptive part in twenty-one pages. A. G.

5. *Handbook of Vertebrate Dissection;* by H. NEWELL MARTIN and WM. H. MOALE. Part II, How to Dissect a Bird. 12mo, 174 pp., cuts. Macmillan & Co. New York, 1883.—This handbook contains a detailed account of the zoological relations and anatomy of the domestic pigeon, with full directions for the beginner as to modes of manipulation and what to observe. The index is comprehensive. It will be found to be a very useful manual for laboratory instruction. A. E. V.

6. *Synopsis of the Fishes of North America;* by DAVID S. JORDAN and CHAS. H. GILBERT. Bulletin of U. S. National Museum, No. 16. 8vo, 1018 pp. Washington, 1883.—In this volume

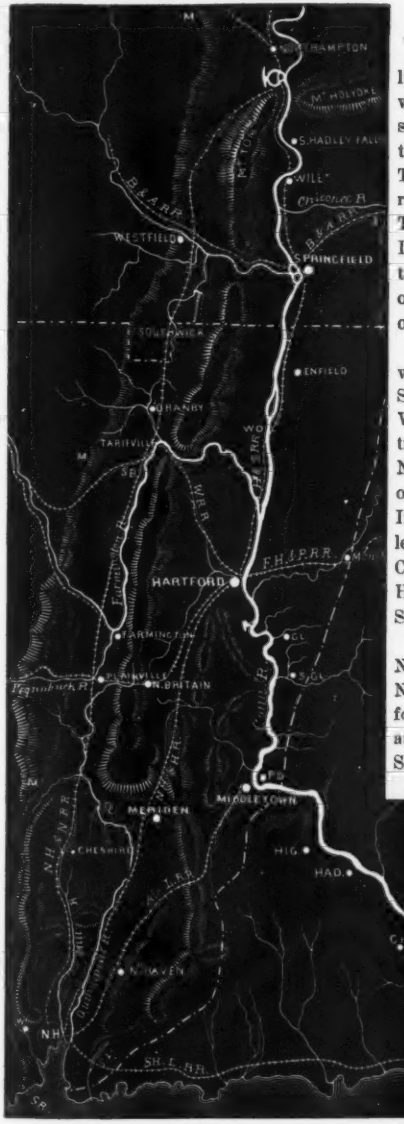
the authors have brought together descriptions of all the families, genera and species, known from North America, both of the marine and fresh-water fishes. The work includes 1340 species, belonging to 487 genera, and 130 families. A large part of the descriptions are original, and when previous ones have been copied, the authors from whom they are taken are properly indicated. The first part of the work was printed in 1879, and the length of time since it was begun has rendered it necessary to print a large appendix, containing corrections and new information of various kinds. A considerable number of new species are included in the work. There is a full table of contents and a copious index. This book will form a convenient and valuable manual of North American fishes. A. E. V.

7. *The Atlantic Right Whales;* by J. B. HOLDER. Bulletin of the American Museum of Natural History, vol. i, No. 4, three large folded plates and one artotype plate. New York, May, 1883.—In this number Dr. Holder has given a detailed account of several specimens, including both sexes, of the small right whale found off our eastern coasts, but much less frequently now than formerly. The paper is accompanied by several large and good plates, illustrating the external appearance as well as the skeleton. The artotype, showing the skull and whalebone, is excellent. A history of the knowledge of this species, which has formerly been much confused, is also included. A. E. V.

IV. ASTRONOMY.

1. *Draper Astronomical Medal.*—At the recent meeting of the National Academy of Sciences, held at Washington (this volume, p. 400), it was announced that Mrs. Mary A. Draper, widow of Professor Henry Draper, had given in trust to the Academy the sum of six thousand dollars, the income of which is to be used "for the purpose of striking a gold medal, which shall be called the Henry Draper Medal, and shall be of the value of two hundred dollars." This medal is to be awarded not oftener than once in two years, to any person in the United States or elsewhere who shall have made an investigation in astronomical physics worthy, in the opinion of the Academy, of this honor. It is further provided that if the income of the fund shall exceed the amount required for the medal, the surplus may be used to assist investigations by a citizen of the United States, in the department of astronomical physics. This gift by Mrs. Draper is a fitting memorial to Dr. Draper, whose labors in this same field were crowned with so brilliant success.

The Solution of the Pyramid Problem by R. Ballard, C. E. (of Malvern, England). 110 pp. 8vo. 1882. (New York, John Wiley & Sons.) This volume, on the objects and uses of the Pyramids of Egypt, aims to show that they were built as the basis of lines and angles for the Egyptian surveyor, that is, to guide in obtaining the meridian lines, fixing directions, measuring angles, and carrying forward a general and detailed survey of the land, and to remain as a corrector or readjuster of boundaries.



EXPLANATIONS.

Dotted line to the east, and the line of heights, M, M, M, to the west, boundaries of the Triassic sandstone, and approximately of the Connecticut valley estuary of Triassic time. North-and-south ridge extending south from Mt. Tom, the Mt. Tom Trap range, or Divide Range, dividing the old estuary area and separating the valley of the modern Connecticut from that of Farmington River and others.

Abbreviations.—In the *western* valley, beginning below: S. R., Savin Rock; N. H., New Haven; W., southern end of West Rock trap range, at Westville; N^{h} H., North Haven; Q., Hough's Mills, on the Quinnipiac; Sb., Simsbury. In the *eastern* or Connecticut valley: SK., Saybrook; ESS., Essex; CH., Chester; HAD., Haddam; HIG., Higganum; PO., Portland Sandstone quarries.

Railroads.—N. H. & N. R. R., New Haven and Northampton; N. H. & H., New Haven and Hartford; Air Line R. R. to Middletown and Willimantic; SH. L. R. R., Shore Line Railroad.

MAP OF THE CONNECTICUT VALLEY REGION SOUTH OF NORTHAMPTON.

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